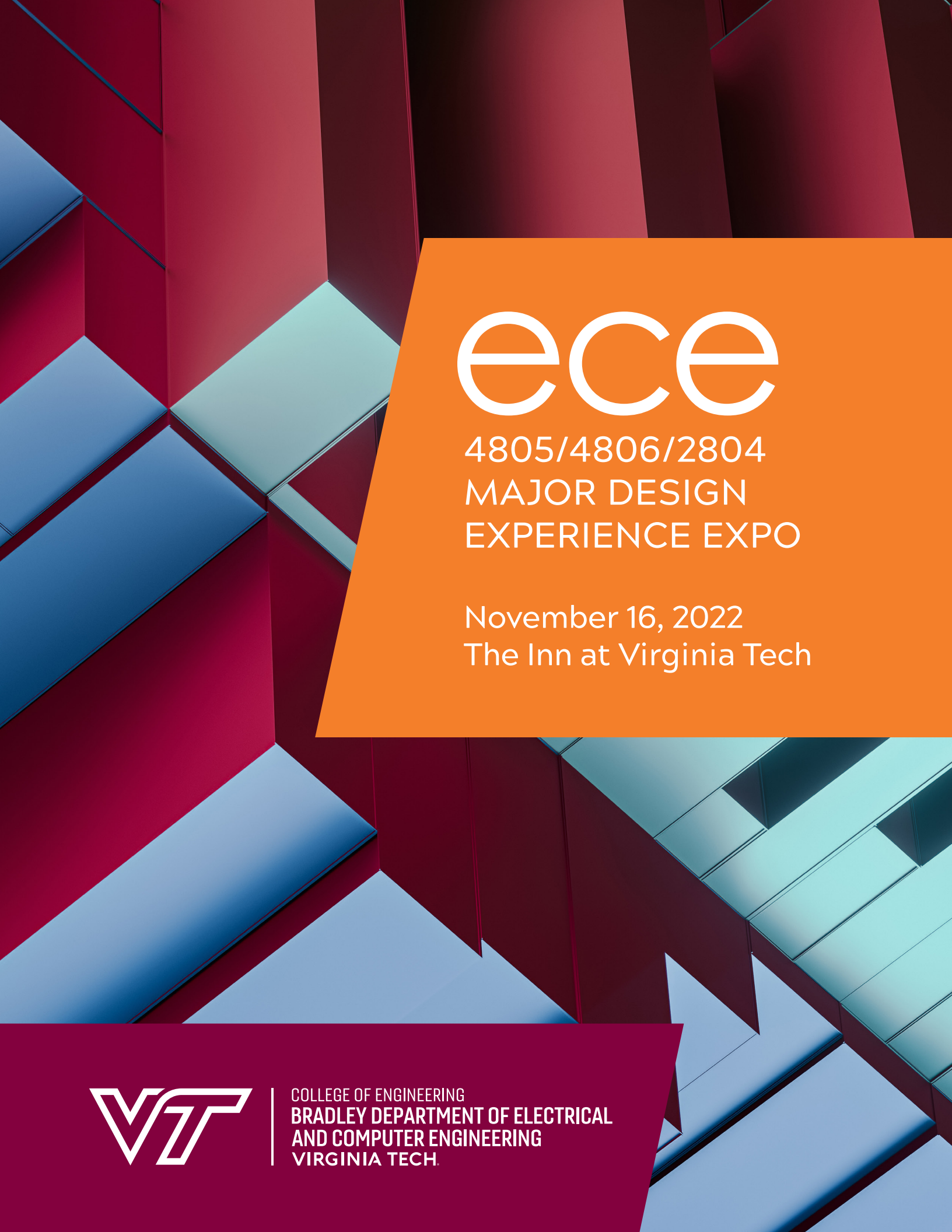

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4805/4806/2804 MAJOR DESIGN EXPERIENCE EXPO

November 16, 2022
The Inn at Virginia Tech

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

AGENDA

Registration	10:30-11 a.m.
Welcome Remarks	11:15 a.m.
Student Presentations	11:30 a.m.- 1 p.m.
Posters	1-1:45 p.m.
Winners Announced	1:45 p.m.
Event Close	2:00 p.m.

PRESENTATION TRACKS

Track 1 - Latham A	Master of Ceremony: Mary Brewer, Judge: Sam Yakuli
AI Multi-Sensor Fusion	Pg. 11
Satellite Navigation Algorithm	Pg. 10
Helium LoRaWAN Decision Software	Pg. 18
Composite Structures	Pg. 14
VT ECE – ECE Degree Planner, Phase 2	Pg. 23
Use & Abuse of Personal Information	Pg. 26
Track 2 - Latham B	Master of Ceremony: Jeff Walling, Judge: Tom Drayer
Coral Jam Machine Learning	Pg. 12
Space Circuit Design Team	Pg. 19
Stabilizing Helicopter Sling Loads	Pg. 24
Prognostic Health Monitor of Power Electronic Converters (PHM PEC)	Pg. 13
Mars RF Relay System	Pg. 21
Thermal Integrity Analyzation In ReRAM Arrays	Pg. 25
Track 3 - Ellett Valley	Master of Ceremony: Toby Meadows, Judge: Mike Penzo
Medication Compliance	Pg. 16
Medication Tamper Detect & Alert	Pg. 17
Geolocation Scanning Rig	Pg. 20
Search and Rescue Robots Swarm	Pg. 15
Wireless Control Algorithms	Pg. 22

SPONSORS

We greatly appreciate their support.

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COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

NORTHROP GRUMMAN

The Bradley Department of Electrical and Computer Engineering's 2022 Fall Major Design Experience (MDE) Expo provides an opportunity for faculty, industry partners, and mentors to interact with 72 undergraduate students on 17 different design teams. For many, this is their first opportunity to work for a real customer on a hands-on project that provides a solution to a specific problem. These team projects showcase the innovation, creativity, and results of our emerging class of undergraduate engineers. The two-semester experience focuses on the design, build, test, and delivery of quality results to their customers. Six unique industry sponsors provided 11 projects and three organizations from within Virginia Tech sponsored the remaining 6 projects. These sponsors serve as the customer throughout the project lifecycle providing feedback and mentorship to the student teams, while creating a pipeline of career-ready individuals.

For these students, much of their undergraduate education was online and remote. While the MDE has returned to an onsite, shared teamwork, and physical lab experience, these engineers have learned to integrate remote coordination and planning into their processes. These skills and experiences should serve them well in their future roles.

We could not have provided our students with these realistic project experiences without the generosity of our industry partners. Half of our current sponsors supported more than one project for this cohort. I'd also like to thank our Virginia Tech directorates, departments, and research centers that are supporting just over one third of our current projects.

Congratulations to each of our students. Their dedication and diligence are evidenced throughout these 17 projects. On behalf of these students and myself, thank you. It is because of our industry sponsors, our subject matter experts, and our MDE faculty that we can provide this tremendous support in developing our next generation of engineers.

Luke Lester
Roanoke Electric Steel Professor and Department Head
Bradley Department of Electrical and Computer Engineering

Welcome to the 2022 Fall Major Design Experience (MDE) Expo where our electrical and computer engineering students will showcase their knowledge, skills, and abilities. We have 72 MDE students working on 17 project teams. We also have one sophomore level Integrated Design Project team sharing their project during the poster session. During the award ceremony, we will also take a few moments to recognize some students who have excelled in the eight courses that comprise our ECE-base curriculum. Those first and second-year undergraduates are already building the foundational knowledge and skills to ensure their future MDE projects will be successful.

The main goal of the MDE program is to provide our ECE students with a realistic, professional engineering experience and to give them a safe environment to grow and learn as they tackle their first engineering project as part of a design team. These students have developed creative strategies to build, test, and deliver final projects. We hope you will take a few moments to discuss how their technical skills, planning, communications strategies, business operations, and teamwork has helped them achieve these results.

These students could not have adapted and delivered these results without the tireless efforts and support of our subject matter experts (SMEs) and more than 15 unique customers across nine different organizations. MDE is made possible because of the dedicated support of our sponsors and subject matter experts. We cannot thank them enough. On behalf of the Bradley Department of Electrical and Computer Engineering, the MDE faculty, and our students, we appreciate your commitment to encourage and facilitate our students. They have emerged from this process as career ready professionals who are prepared to make lasting contributions to society by engineering and delivering quality solutions that address our most important societal needs.

The MDE program would like to thank Luke Lester for his vision to establish the MDE program and for his continued support in every aspect of the program. Special thanks to the instructors and teaching assistants who have made this all possible. Because of each of you, we are all better indeed!

To our ECE students: Your culminating experience wasn't without its challenges, but you committed to the process and as a result, have produced exceptional results. You stand at the door to becoming contributing engineers! And as VT ECE Hokie engineers, be certain that you are ready to invent the future in the spirit of "Ut Prosim" (That I may serve)!!!

J. Scot Ransbottom
Director of Design Projects
Bradley Department of Electrical and Computer Engineering

Project Leadership

This class is only possible because of the commitment, dedication, and spirit of the following Customers and Subject Matter Experts. Thank you!

Sponsor	Customers	Project	Subject matter expert (SME)
Aerospace Corp.	John Janeski, Alexander Utter, Steven Spry, Howard Ge	Satellite Navigation Algorithm	Greg Earle, Samantha Kenyon
Aerospace Corp.	Michael Nemerouf	AI Multi-Sensor Fusion	Nektaria Tryfona
Aerospace Corp.	Adam Belhouchat, Donna Branchevsky	Coral Jam Machine Learning	Nektaria Tryfona, Shelley Stover
Collins Aerospace	Debabrata Pal	Prognostic Health Monitor of Power Electronic Converters (PHM PEC)	Shuxiang (William) Yu, Narayanan Rajagopal
Collins Aerospace	Steven Kestler, Charlene Hu, Jaynesh Patel, Saul Montano	Composite Structures	Dong Ha, Zhuqing Zhao
Collins Aerospace	Giovanni Franzini, Stefano Riverso, Marcello Torchio	Search and Rescue Robots Swarm	Ryan Williams, Larkin Heintzman, Kevin Smith
Impruvon Health Corp.	Justin Amoyal	Medication Compliance	Creed Jones
Impruvon Health Corp.	Justin Amoyal	Medication Tamper Detect & Alert	Creed Jones
Jump Trading	Andrew Millard	Helium LoRaWAN Decision Software	Leonard Smith
Northrup Grumman, Space Systems	Randy Spicer, Julianna Neumann	Space Circuit Design Team	Jeffrey Walling
PricewaterhouseCoopers	Hans Tercek, Marc Mazzie, Brian Dunch, Patrick Parodi, Srdjan Marinovic	Geolocation Scanning Rig	Tim Talty
Virginia Space Grant Consortium	Louis Beex	Mars RF Relay System	Louis Beex
Virginia Tech ECE	Carl Dietrich	Wireless Control Algortihms	Carl Dietrich, Daniel Jakubisin, Mayur Dhepe
Virginia Tech ECE	Mary Brewer, Nicole Gholston	ECE Degree Planner, Phase 2	Bill Plymale, Scot Ransbottom, John Ghra
Virginia Tech ECE	Mary Lanzerotti, Gegorio Nasaspaceton	Stabilizing Helicopter Sling Loads	Mary Lanzerotti
Virginia Tech ECE	Marius Orlowski	Thermal Integrity Analyziation in ReRAM Arrays	Amrita Chakraborty
Virginia Tech Hume Center	Alan Michaels	Use & Abuse of Personal Information	Alan Michaels, Christopher Henshaw

Guest speakers

In addition to our project sponsors and subject matter experts, there were many others who significantly contributed to the success of this class. We want to take this opportunity to express our deep-felt appreciation and thanks for their contributions.

Shelley Stover

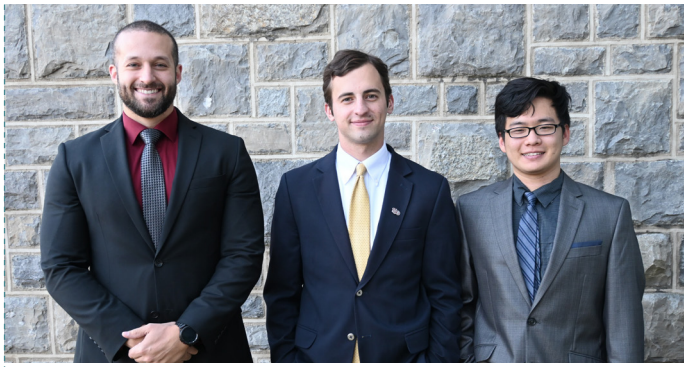
Communications

Sal Bezos, Mark Mondry, and Corwin Warner

Innovation and Intellectual Property Management

PROJECT TEAMS

Satellite Navigation Algorithm



LEFT TO RIGHT: Jeremy Bruce, Matthew McLaughlin, Aaron Yang
SME: Greg Earle, Samantha Kenyon

CHALLENGE

Develop and implement the code for sensor fusion algorithms to receive data from an Inertial Measurement Unit (IMU), a magnetometer, and sun sensors stored on a cube satellite prototype, and translate them into the correct coordinate frames. This data will determine the prototype's position, attitude, and time, then will be used to determine the new position and attitude of the "cube sat."

Jeremy Bruce Richmond, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I seek to develop products that enhance the lives of people. I am currently seeking jobs in the fields of game development and smart city infrastructure.

Class Comment: This course exposes students to valuable industry scenarios and forces the team to develop strategies for overcoming realistic challenges.

Aaron Yang Crewe, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I wish to gain a general understanding that allows me to work to advance all fields of science.

Class Comment: The class has helped us by allowing us to anticipate challenges and prepare to either prevent or overcome them.

Matthew McLaughlin Baltimore, Md.

Bachelor of Science in Electrical Engineering
Radio Frequency & Microwave

Aspirations: I want to further my RF experience in the workplace by working in the aerospace/defense industry.

Class Comment: This course provided valuable experience in working with engineers across different disciplines, as well as learning how to continue to progress forward despite seen and unforseen setbacks.

CUSTOMERS: JOHN JANESKI, ALEXANDER UTTER, STEVEN SPRY, HOWARD GE

AEROSPACE

AI Multi-Sensor Fusion

LEFT TO RIGHT: Nathan Harvey, Gustavus de Andrade, Matthew Hardmon | **SME:** Nektaria Tryfona

CHALLENGE

To design, test, and compare the performance of AI-based models that can input GPS and Inertial Measurement Unit (IMU) data and predict the true position of the sensors' source. This project could potentially aid in the error correction of sensor systems that are utilized for Position, Navigation, Time (PNT) purposes.

Gustavus de Andrade Springfield, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I aspire to be a core contributor to projects that significantly progress modern technologies.

Class Comment: The systems engineering I have learned from all our mentors over the course of the class has given me a new perspective on how engineering works in industry.

Matthew Hardmon Chantilly, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I want to do something that I find enjoyable while simultaneously making a positive impact on the lives of others.

Class Comment: This course should be the model for all courses in terms of structure. You don't need a customer or anything that extensive to achieve what this course has done. It has allowed students to simulate realistic scenarios in which we are assigned a project and a team, and it is up to us to communicate and execute.

Nathan Harvey Centreville, Va.

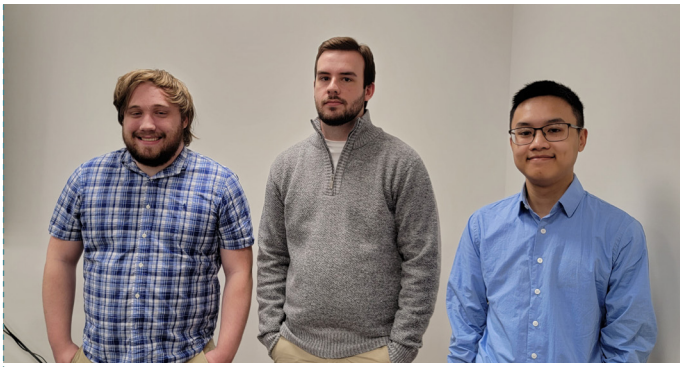
Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: I hope to contribute towards creative software solutions that can help ease burdens on people's lives by developing automation for key tasks, working on embedded systems, or contributing to ML research.

Class Comment: This course has been instrumental in teaching me how to manage time when working on long-term group projects, as well as helping me to build both technical skills and a greater familiarity with designing and tracking metrics for success in projects.

CUSTOMER: LAM ANSON

Coral Jam Machine Learning



LEFT TO RIGHT: Jacob Lowe, Sean Pack, Luc Phan
SME: Shelley Stover, Nektaria Tryfona

CHALLENGE

This project utilizes machine learning to counteract the effects of GPS jamming. Using a feed-forward neural network, the model acts as a filter removing jamming noise. The model is scaled to run on Small Weight and Power (SWaP) devices to be deployed in the field.

Sean Pack Roanoke, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I want to work in HPC computing developing efficient parallel processing for ML applications.

Class Comment: The course provided opportunities to develop planning and professionalism skills not available in the classroom.

Luc Phan Roanoke, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: Apply my studies to aid in the development of systems that will improve the lives of many.

Class Comment: This course prepared me for the workflow of the workforce. I learned techniques for planning and execution that will be helpful in the future.

Jacob Lowe Asheville, N.C.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

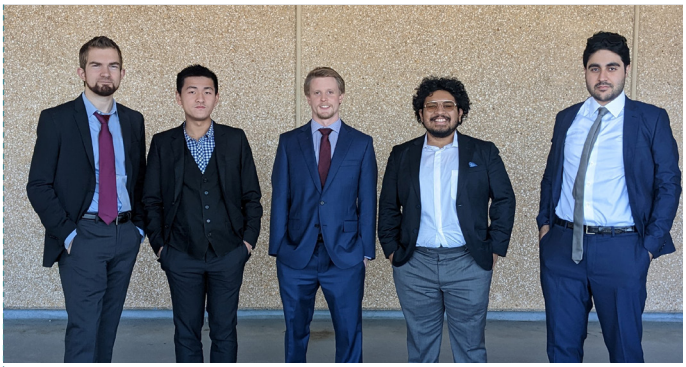
Aspirations: Helping to improve lives with large scale software implementations, mostly for commercial use.

Class Comment: This course helped me prepare for how team/project based work will operate during my time as an engineer. It gave me my first true test run into how I will be in the workforce.

CUSTOMERS: ADAM BELHOUCHAT, DONNA BRANCHEVSKY

AEROSPACE

Prognostic Health Monitor of Power Electronic Converters (PHM PEC)



LEFT TO RIGHT: Corwin Warner, Li You, Jeffrey Chambliss, Luis Yon, Kourosh Khoie | **SME:** Shuxiang (William) Yu, Narayanan Rajagopal

CHALLENGE

To design a system capable of predicting the remaining lifetime for a generic Power Electronic Converter (PEC). This methodology may be used for larger scale Power Electronic Converters, along with different types of Power Electronic Converters including DC-AC, AC-DC, and DC-DC, using MOSFET or IGBT switching logic.

Corwin Warner Leesburg, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I want to design and develop equipment using embedded systems that will change the way people interface with technology in their lives.

Class Comment: Learning how to manage and complete a design project in this course has proven to be a valuable skill in my daily life and I'm thankful for the opportunities presented and provided by this experience.

Li You Fuzhou, China

Bachelor of Science in Electrical Engineering
Photonics

Aspirations: I enjoy the process of doing the research and coming up with new ideas that will have a significant impact on the lives of people.

Class Comment: Learning how to begin from scratch with some basic ideas and develop those ideas into verifiable products with collaboration and teamwork.

Kourosh Khoie Tehran, Iran

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I aspire to create digital content that can provide fun and valuable experiences.

Class Comment: I've enjoyed working to develop equipment that can help clients and people in real-world scenarios and to learn better ways to operate in an 'authentic' engineering team experience.

Jeffrey Chambliss Virginia Beach, Va.

Bachelor of Science in Electrical Engineering
Micro/Nano Systems

Aspirations: I want to design quality electronic systems in a wide range of applications including consumer electronics, aerospace and defense systems, and sustainable solutions.

Class Comment: This course has shown me that the engineering process is not as smooth as one would first expect. I now have the mindset to expect unexpected hardships in my career and act accordingly to meet specifications while reducing negative tradeoffs as much as possible.

Luis Yon Norfolk, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronics Systems

Aspirations: I want to be a part of the process in the design, testing, and validation of different devices and systems in the automotive, aerospace, and power industry.

Class Comment: The design experience under time and budget constraints has been illustrated well within this year long project and being a part of a team that's able to problem solve and address issues as quickly as possible has been a memorable experience.

CUSTOMER: DEBABRATA PAL

Collins Aerospace

Composite Structures

LEFT TO RIGHT: Kevin Vo, Shashank Vasanth, Kien Tran
SME: Zhuqing Zhao, Dong Ha

CHALLENGE

To construct a machine learning algorithm capable of categorizing and localizing data from images of nacelle damage. Our abstraction was capable of categorizing and localizing on steel data as well as handling the preprocessing required to input nacelle data into the model.

Shashank Vasanth Nashua, N.H.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: My career goal is to become the CTO of a major software company and help the company continue to change the world.

Class Comment: I appreciate being partnered with an industry sponsor and exposed to novel engineering problems faced today. The systems engineering skills I have learned have already proven valuable outside this course.

Kevin Vo Clifton, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My career goal is to become a software engineer and help make a difference in the world with my company.

Class Comment: This course provided us with tons of hands-on experience and helped me prepare myself through professional settings. The course also helped develop engineering that are valuable outside of this course.

Kien Tran Roanoke, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I aspire to be a product manager in the future, where I can fill the gap between business and engineering.

Class Comment: I'm really glad that we got the client that we did, Collin Aerospace. Steven was a great client and I really enjoyed working with him. My team was amazing as well.

CUSTOMERS: STEVEN KESTLER, CHARLENE HU, JAYNESH PATEL, SAUL MONTANO

Collins Aerospace

Search and Rescue Robots Swarm

LEFT TO RIGHT: Mahmoud Elsayed, Alejandra Caceres, Mohammed Zaheer, Osama Owis | **SME:** Ryan Williams, Larkin Heintzman, Kevin Smith

CHALLENGE

To implement a real time autonomous planner utilizing GPS coordinates on multiple drones in order to find a pathway to lost individuals. Additionally, to create prototype hardware enclosures to protect the electrical components from weather effects.

Mohammed Zaheer Gaithersburg, Md.

Bachelor of Science in Electrical Engineering
Energy & Power Electronics Systems

Aspirations: My career goal is to work with renewable energy and to further its advances. I hope to utilize my skills and abilities to make a difference in the field.

Class Comment: This course gave me more insight into how the industry works and I learned important skills that I believe I will utilize throughout my career(s).

Mahmoud Elsayed Cairo, Egypt

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: My aspiration is to work in the automation industry. I aspire to use the skills I have acquired at Virginia Tech to help others and eventually take on a leadership position.

Class Comment: This course helped me learn how real-world problems can be approached. It also helped me improve my technical and soft skills.

Osama Owis Roanoke, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: My goal is to work in the robotics and autonomy industry, as I believe this is where the future is heading. I hope to learn the state of the art technologies to further enhance my skills.

Class Comment: The course made me learn how a typical design cycle would work in the industry as well as giving me experience interacting with customers.

Alejandra Caceres Cochabamba, Bolivia

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

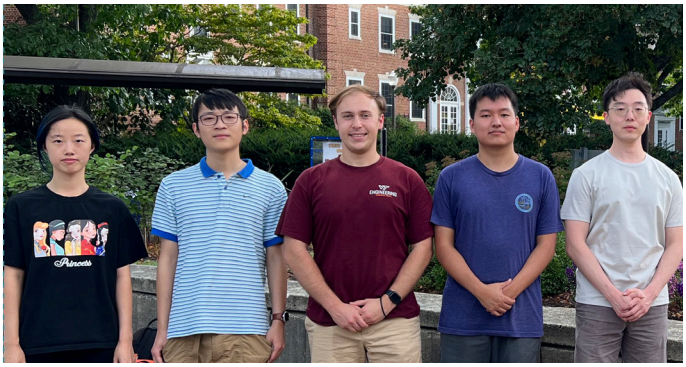
Aspirations: I aspire to expand my knowledge, work in the cybersecurity industry, and explore other career paths. I want to enhance the skills learned at Virginia Tech as well as inspire other women to pursue a degree in engineering.

Class Comment: Taking this class was a valuable experience. It taught me to work collaboratively in different group environments while helping me refine my soft and technical skills.

CUSTOMERS: GIOVANNI FRANZINI, STEFANO RIVERSO, MARCELLO TORCHIO

Collins Aerospace

Medication Compliance



LEFT TO RIGHT: Jiaye Liu, Ming Lu, Alex Parrott, Daniel Shin, Hansu Kim | **SME:** Creed Jones

CHALLENGE

Design an app interface and program that will allow a user to take a photo using their smartphone of a blister packet and barcode allowing the blister packet to be analyzed for correct medication administration, and sending that information to the designated locations for notification of success or failure of medication compliance.

Daniel Shin Oakton, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: My career goal is to work as a software engineer while broadening my knowledge in computer engineering. Later in life, I would like to make an extensive video game.

Class Comment: Working with a company was a valuable experience and, through the mentor and SME, it was a wonderful learning environment.

Jiaye Liu Changzhou, China

Bachelor of Science in Computer engineering
Machine Learning

Aspirations: I want to continue my studies in computer engineering for graduate education. Then I will continue to work on mechanical learning or software development in artificial intelligence in my future career.

Class Comment: It was my first time working with the company, and the professional experience gave me a lot of knowledge that I will use in the future. At the same time, this class also gave me a more comprehensive understanding of the future work of engineers.

Alex Parrott Lawrenceville, Va.

Bachelor of Science in Electrical Engineering
Micro/Nano Systems

Aspirations: I plan to further my education and obtain a Master's of Science in Electrical Engineering, and then use my education to pursue the development of medical devices that function as closed loop body monitoring and drug delivery systems.

Class Comment: I have found the design experience to be engaging and useful for understanding how industry projects bridge together the technical work with other aspect of a business, such as customer relations. Being dynamic and able to change the project quickly is a major skill this course has helped me develop.

Ming Lu Changzhou, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I will go to graduate school to gain a deeper understanding of machine learning and computer vision. After that, I want to open a company to apply all the knowledge I got from school to medical-related areas.

Class Comment: This course gave me a chance to solve a real-life problem with the knowledge I learned within my four years of journey, this will make me more competitive in future study and work.

Hansu Kim Gwangju, South Korea

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

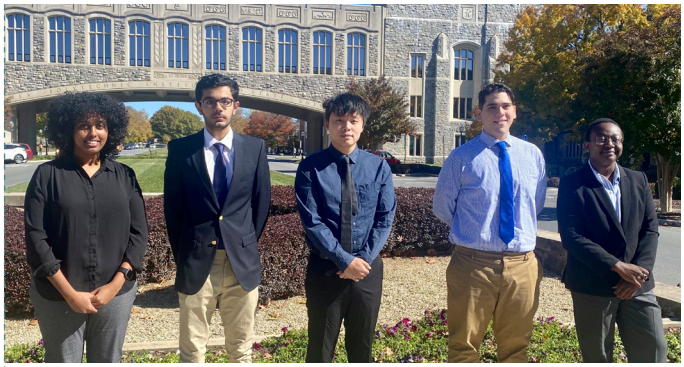
Aspirations: My aspiration is to gain experience and improve upon my skill and knowledge as a software engineer. After I graduate, I would like to continue to learn and experience working on software engineering and hardware design in my future career.

Class Comment: Taking this course presented me with the opportunity to work with a company as a group of engineers. This kind of opportunity is a valuable resource in the course of engineering career.

CUSTOMER: JUSTIN AMOYAL

ImpruvonHealth

Medication Tamper Detect & Alert



LEFT TO RIGHT: Yeab Lakew, Abdul Hadi Imran, Taotao Wang, Kyle Bugeja, Shane Smith | **SME:** Creed Jones

CHALLENGE

To design and develop an IoT device that can reduce medication logging error and medication administration error for nursing homes and other residential facilities. The system will be able to dispense and keep track of connected and separated pill packs. The system consists of medication tamper detection, medication dispensing, and logging features.

Taotao Wang Shanghai, China

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: To give my best professional work and enhance my knowledge while contributing in the software development field.

Class Comment: This course better prepared me for the industry environment and enhanced my communication skills.

Abdul Hadi Imran Lahore, Pakistan

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: To be well-versed in several coding languages.

Class Comment: This course provides great hands on experience with project management in a professional setting.

Kyle Bugeja New York, N.Y.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: To be an effective team member.

Class Comment: This course created a wonderful environment to foster team-based experiences and commitments.

Yeab Lakew Arlington, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronic Systems

Aspirations: To work in the field of clean energy and help with the transition to renewable energy sources.

Class Comment: This course allowed me to experience project management in a prolonged setting as well as develop my communication skills among fellow engineers and clients.

Shane Smith Stafford, Va.

Bachelor of Science in Computer Engineering
Administrative Engineering

Aspirations: My career goal is to become a proficient optimization engineer in the medical field to help provide better services for patients and those who look after their health.

Class Comment: This course allowed me to experience the ever-changing demands of the medical and engineering fields alike. I was fortunate to be partnered with not only a dedicated team, but also a sponsor who is passionate about his line of work!

CUSTOMER: JUSTIN AMOYAL

ImpruvonHealth

Helium LoRaWAN Decision Software

LEFT TO RIGHT: Pei Yingqi, Ken Atta-Boakye Jr., Noah Meine, Christopher Forgash | **SME:** Leonard Smith

CHALLENGE

Design and build a software model predicting the coverage and expected mining return of a Helium Hotspot at a given location and antenna configuration. This information can be used by Jump Crypto in support of their mission to expand and foster the Helium and Crypto communities.

Noah Meine Burke, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I hope that throughout my career I can make a lasting impact for good. I hope that I can help those in need and be a positive contributor in the lives of people I work with and who are impacted by my work.

Class Comment: This class gave me the opportunity to gain experience in a multi-semester project. It was challenging and rewarding.

Christopher Forgash Leesburg, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: Throughout my career I hope to make meaningful contributions to the Machine Learning Community. I will be starting as a Software Engineer in early 2023 and am excited to begin the challenge of working full time. I am also planning to pursue my Master of Engineering degree through Virginia Tech in the area of Machine Learning to further my opportunities in this field.

Class Comment: This course wholeheartedly delivered on the opportunity to participate and lead a major design experience. The ability to work with industry professionals while honing new skills that we may not have had a chance to develop during our normal coursework was priceless.

Ken Atta-Boakye Jr. Woodbridge, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I have found a love for problem solving and a passion for coding. Combining these two traits has lead me to a pursuit of becoming a software engineer. I am proud to announce that I have a full time job lined up after I graduate as software engineer and I can't wait to utilize the skills the school has taught me and be of use to the company!

Class Comment: This course has given me a real preview of what it means to be an engineer. It has shown me the process of planning, formulating ideas, and teamwork. I am glad I was able to have this experience so I can reflect on it in the workplace.

Pei Yingqi Sichuan, China

Bachelor of Science in Computer Engineering
Machine Learning

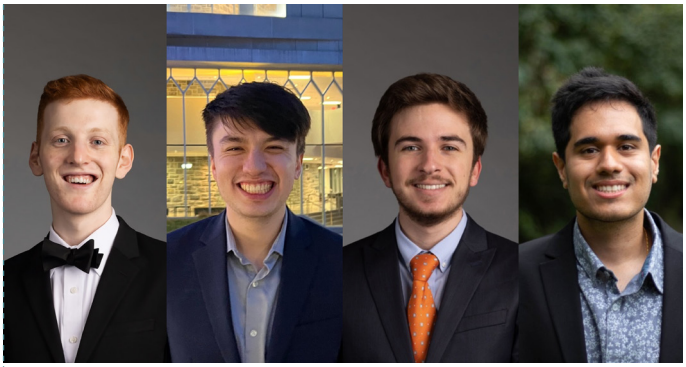
Aspirations: I'm interested in different machine learning related research programs and participated in several undergraduate research projects and published a paper. I'm going to VT graduate school and my aspiration would be persuing an Ph.D. degree.

Class Comment: I have learned how a real engineer would work and gained many helpful industrial experiences that I could not get from my research programs. It also helps me communication better with others.

CUSTOMER: ANDREW MILLARD

jumptrading

Space Circuit Design Team



LEFT TO RIGHT: Jean-Luc DeRieux, Brandon Reasoner, Nicola Belfiore, Ishaan Bhambra | **SME:** Jeffrey Walling

CHALLENGE

To design and build both the driver and controller for a magnetorquer that will rotate a satellite in Low Earth Orbit. The solution must be able to generate 1000 A/m^2 and be resistant to the conditions of space.

Jean-Luc DeRieux King George, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy
Machine Learning

Aspirations: As an Electrical Engineer, I would like to use my skillset alongside my creativity to create new and innovative devices that help society.

Class Comment: This course provided me the opportunity to get hands on experience with working for a real client.

Ishaan Bhambra Baltimore, Md.

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: As a CPE with a Controls, Robotics, and Autonomy major I would like to put my skillset to use by working with autonomous technologies such as self driving vehicles and autonomous medical robots to help better and change society.

Class Comment: Helped provide an insight on how to engineer a solution in a team to solve a problem that can be seen in industry with insight from the customers perspective and help of mentors.

Nicola Belfiore Davie, Fla.

Bachelor of Science in Computer Engineering
Chip-Scale Integration

Aspirations: As a CPI major in CPE, I aspire to continue to push the boundaries of computer processing and memory through VLSI.

Class Comment: Working with customers to design a specified deliverable has given me a lot of experience in asking the right questions and discussing specifications/progress.

Brandon Reasoner Bridgewater, N.J.

Bachelor of Science in Electrical Engineering
Optics, Space Systems

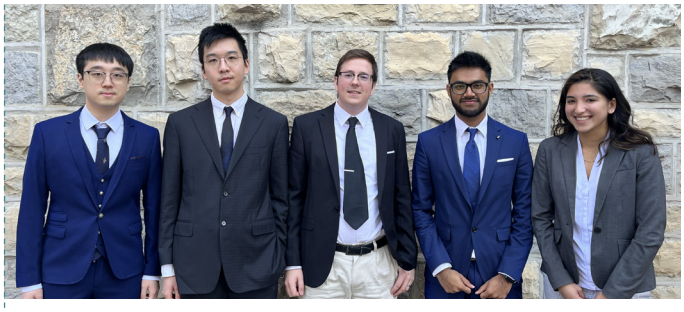
Aspirations: An an EE, I want to work on large project to "move the needle" on human capabilities.

Class Comment: Working on more practical matters allows for the use of all of our skills instead of a singular theoretical classes.

CUSTOMERS: RANDY SPICER, JULIANNA NEUMANN

NORTHROP GRUMMAN

Geolocation Scanning Rig



LEFT TO RIGHT: Shiqian Li, Minzhou Pan, Luke Smith, Hunain Ali Shamsi, Pratistha Yadav | **SME:** Tim Talty

CHALLENGE

To redesign the Indoor Geo-location Platform Scanning Rig. Focuses on lowering size, weight, and power. Relies on a signal-capture process to build a database of location fingerprints for devices to reference. The scanning rig captures and stores data of proximal Wi-Fi and Bluetooth LE signals upon user mobile device command using a mobile application, formats data according to PwC specification, and stores data in a removable USB storage device.

Hunain Ali Shamsi Muscat, Oman

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My goal is to work at a space or networking related industry for a few years and then work on my own media business as an entrepreneur.

Class Comment: This course was very helpful in understanding and experiencing how the real-life engineering industry works. It gave me a lot of exposure and hands-on experience.

Luke Smith Tangier, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: After graduation I will be working for the Virginia Tech National Security Institute. I will be using the valuable skills learned in this course to conduct research on and assist in the development of secure digital communications.

Class Comment: This course has provided me with the invaluable opportunity of working with a tremendous team to develop a solution for an open-ended problem.

Shiqian Li Chengdu, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: My career goal is to work as an innovator, ready to help achieve company goals. I am motivated to learn, grow, and excel while working.

Class Comment: This course gave me hands-on experience with HTML, CSS, and javascript, as well as experience with writing formal document and preparing presentations in a professional setting. This helped ready me to work in professional environment.

Pratistha Yadav Chantilly, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My plan after graduation is to complete my masters in Computer Engineering and to work in an aerospace company that would allow me to rotate to different positions between hardware and software.

Class Comment: This course has helped me further develop my communication and hardware skills. I learned some debugging techniques that I will carry with me to the workplace!

Minzhou Pan Hangzhou, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I plan to devote more time and experience to artificial intelligence research after graduation and I am looking forward to promoting the development of general artificial intelligence.

Class Comment: This class developed my ability to collaborate with a team and taught me how to develop in embedded systems.

CUSTOMERS: HANS TERCEK, MARC MAZZIE, BRIAN DUNCH, PATRICK PARODI, SRDJAN MARINOVIC

pwc

Mars RF Relay System

LEFT TO RIGHT: Jian Song, Raymond Daniels, Jarod Horne, Danny Flynn, Mark Higgins | **SME:** Louis Beex

CHALLENGE

To design and build a demonstration RF relay communication system that will communicate over-the-air for over the horizon RF communication on Mars. The relay will be assumed to consist of several autonomous helicopter drones, similar to Ingenuity, serving as repeater stations, and must satisfy the various constraints in effect on Mars. Some of these major requirements included a system weight under 500g, a size under 1000cm^3, a storage size of at least 100GB, packetized data, short flight and/or hover times, and limited transmit and/or receive times.

Jarod Horne Yorktown, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I want to work on improving the infrastructure and power systems at NASA Langley. I worked as an intern for the past 4 summers at Jacobs Technology which is NASA Langley's prime contractor for Engineering, Maintenance, and Operations. They have offered me a position for electrical engineering starting in January 2023 after I graduate and I have accepted their offer.

Class Comment: This class was a good dress rehearsal for what design projects will be like in the industry. Having worked on several projects for Jacobs Technology/NASA Langley, there are many similarities to the process we used in this class and the process used at my internships. I enjoyed the collaboration and cooperation on this project as everyone had a part to play to ensure success of the project.

Raymond Daniels Spotsylvania, Va.

Bachelor of Science in Electrical Engineering
Space Systems

Aspirations: I've come to love nearly everything about space and aviation, so I'm looking to expand society's capabilities for deep space exploration. I would love to do so through work with avionics on spacecraft/launch vehicles, vehicle systems, or human factors systems interactions.

Class Comment: I enjoyed being a part of this course. It helps synthesize what I've learned throughout my undergrad into something that I would enjoy working on. The chance to see a project from conception to a final product is invaluable experience. The class helped me understand the many interconnecting sub-systems that are involved in communication.

CUSTOMER: LOUIS BEEX

Danny Flynn North Potomac, Md.

Bachelor of Science in Electrical Engineering
Communications & Networking

Aspirations: I want to design the communication systems we use to talk to future astronauts - in other words, I'd like to bring the Internet to Mars and beyond!

Class Comment: The MDE has allowed me to obtain practical RF and communications experience and learn about some of the issues that don't arise when studying these things from a "textbook" perspective.

Jian Song JiangXi, China

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: To pursue a career in Power systems

Mark Higgins Fairfax, Va.

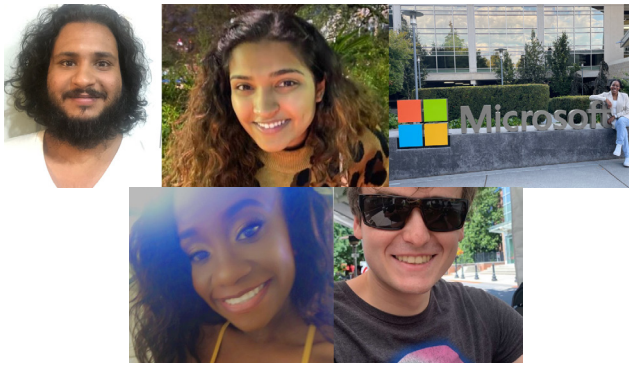
Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I want to do space and defense contracting and one day become a project manager. I am very passionate about improving our military's technical capabilities.

Class Comment: This class really helped me understand the life cycle of a project in the industry and how to manage time efficiently. In addition, it gave me experience with presenting to a customer, working with subject matter experts, and giving design presentations.

VIRGINIA SPACE GRANT CONSORTIUM

Wireless Control Algortihms



LEFT TO RIGHT, TOP TO BOTTOM: Hitesh Kumar, Kaushiki Valluri, MK Ntantang, Joshae Gordon, Connor Mcpeak
SME: Carl Dietrich, Daniel Jakubisin, Mayur Dhepe

CHALLENGE

To build a learning tool accessible via Canvas teaching underwater wireless communications. This project extends the HLSI program, which focuses on above-ground RF communication; our senior design project, on the other hand, focuses on acoustic communications in underwater environments.

Hitesh Kumar Ashburn, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: My career goal is to be happy and useful, I do not have specifics or requirements beyond that.

Class Comment: I enjoyed getting to know all my team members and learn to work on a problem that is not well-defined.

MK Ntantang Nanjing, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I want to start a company that disrupts an existing industry, process, or standard. I want to work in a fast-paced, high-demand environment with tangible and meaningful results.

Class Comment: This course gave me hands-on experience with circuit design and troubleshooting, as well as experience with formal presentations in a professional setting. This will help me as I move from an academic setting to a professional one.

Joshae Gordon Kingston, Jamaica

Bachelor of Science in Computer Engineering
Computer Engineering (general)
with a focus in Human-Computer Interactions

Aspirations: I would like to work for an innovative company that supports my interests in Human Computer Interaction, User Experience (UX), and AR/VR Technology.

Class Comment: The course has provided me with the experience of implementing user-based material to a create a satisfying customer experience. To be able to design, navigate through complex code, and present information is extremely rewarding as an aspiring Computer Engineer.

Kaushiki Valluri Leesburg, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity
with a focus in Leadership

Aspirations: I want to start my own contracting company primarily working for the Government in defending the nation from cyber attacks.

Class Comment: Something that I have learned from this class is how to apply the Engineering knowledge that I have learned over the past 4 years and convert it to be used in an environment that is very similar to the working life. This class has helped me learn and get an understanding of the transition from being a college student to starting work in the real world. It has definitely been a great learning experience for me.

Connor McPeak Minneapolis, Mn.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I would love to be a Cyber Security Consultant.

Class Comment: The customer interactions required for this course gave me real world experience proposing ideas to someone who was unsure of the result they wanted.

CUSTOMER: CARL DIETRICH

ECE Degree Planner, Phase 2

LEFT TO RIGHT: Lauren Anderson, Joseph Petruzziello, Wejdan Alnofeiy, Zhu Runchen, Chenyi Wang | **SME:** Bill Plymale, Scot Ransbottom, John Ghra

CHALLENGE

To design and build a one-stop shop tool for ECE students to plan their degrees that incorporates their own course history to validate their plan of study against the checksheet for their academic year and major, and for ECE advisors to add, update, and delete courses and majors while updating the curricula.

Lauren Anderson Houston, Tx.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My career goal is to work as a software developer at a company specializing in satellite imagery. It is a dream of mine to see code that I helped develop be used on a satellite.

Class Comment: This course gave me hands on experience for developing a product for a customer and helped with my professional development and presentation skills. I also learned a lot about troubleshooting and resolving problems.

Chenyi Wang Zhejiang, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: To utilize the skills I have learned to make possible contributions to the continued development and innovation of technology

Class Comment: This course gave me the opportunity to work on a capstone project while helping me to improve my teamwork, communication, planning, and problem solving skills.

Zhu Runchen Jiangsu, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I would like to apply this knowledge and experience to my future career.

Class Comment: This course gave me the experience of working with teammates to build a product for customers and taught me how to be a good engineer.

Wejdan Alnofeiy Jeddah, Saudi Arabia

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: To pursue a career in information and operational security in the ever-evolving realm of cyberspace.

Class Comment: This course has provided me with a chance to see a long-term project from start to finish. The hands-on experience and ability to learn and adapt to new obstacles along the way will be invaluable as I enter the workforce.

Joseph Petruzziello Tarboro, N.C.

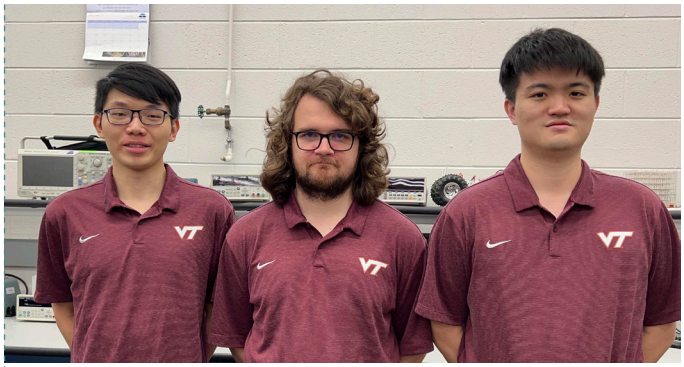
Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: Obtain a job in Computer Engineering dealing with embedded systems.

Class Comment: This course has given me a hands on opportunity to work on a real applicable group project. There are some classes within the CPE major that require group work, but it's always been a max of two or three people total within the group. This experience has helped me understand real world project work applications with a customer, a boss, and working with multiple teammates.

CUSTOMERS: MARY BREWER, NICOLE GHOLSTON

Stabilizing Helicopter Sling Loads



LEFT TO RIGHT: Duy Nguyen, David Reineke, Luyi Tang
SME: Mary Lanzerotti

CHALLENGE

The aim of this work is to demonstrate a physical model of the new stabilization method. By demonstrating and comparing the physical results to the previously simulated models, the practicality of the method can be obtained. The application of this method will involve gyroscopically measuring the angle of the payload load, as well as the ability to directly control the length of the payload line. The application of both a microcontroller to the motor system and a gyroscope to the payload will allow for an automated stabilization system that can be enabled and disabled with the toggle of a switch.

Duy Nguyen HoChiMinh, Vietnam

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: My career goal as an electrical engineer is to create and deploy defensive systems against a variety of security issues using my understanding of threats and vulnerabilities.

Class Comment: I gained practical experience with circuit design and debugging in this course, as well as with formal presentations in a work environment.

Luyi Tang Shanghai, China

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: I want to make robots that can improve lives and develop control algorithms that can make robots do tasks more efficiently.

Class Comment: The course provided real world experience to us and I think it will be helpful in my career.

David Reineke Saint Charles, Mo.

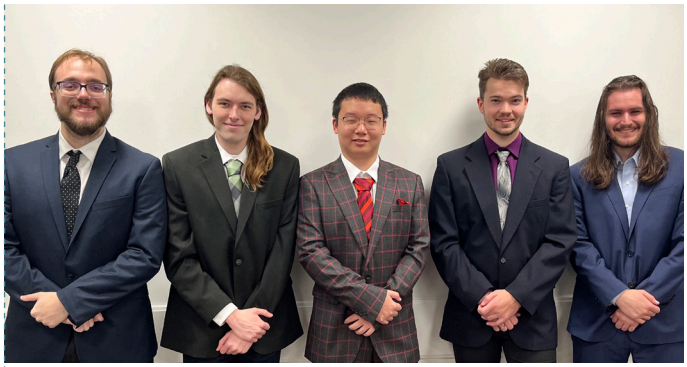
Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: To develop cutting edge robotics that are used in space travel and furthering humanity.

Class Comment: This course provided me with practical in-the-field experience and allowed me to have a better understanding of an actual workplace.

CUSTOMERS: MARY LANZEROTTI, GEGORIO NASASPACETON

Thermal Integrity Analyzation in ReRAM Arrays



LEFT TO RIGHT: Max Crochet, Zachary Wilson, Shenkai Zhou, Chandler Clements, Payton Fallen | **SME:** Amrita Chakraborty

CHALLENGE

To target and analyze the temperature dissipation rates within a ReRAM device during testing and usage. This is accomplished with a 1:1 scale virtual model based on current devices, and is behaviorally validated with a Python Script Library.

Maximilian Crochet Gainesville, Va.

Bachelor of Science in Electrical Engineering
Micro/Nano Systems

Aspirations: To pursue a job that will allow for me to explore and learn more about electronics and how things work.

Class Comment: This course has allowed me to learn the design flow process of a product and how to properly interract with customers, professionals, and fellow team members. It also has reiterated the importance of scheduling and dividing labor.

Zachary Wilson Poquoson, Va.

Bachelor of Science in Electrical Engineering
Micro/Nano Systems

Aspirations: To pursue further education to the Ph.D. level, and to work as a research engineer.

Class Comment: This course has provided me the chance to work on research-related projects as a gateway to future educational opportunities.

Shenkai Zhou Yangzhou, China

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: To innovate, and to work my way into a position where I have the ability to change the world in my field.

Class Comment: This course has taught me to design models on my own, allowing me to share my skills and thoughts, and gave me a chance to improve my communication skills and connections with other people.

Chandler Clements Midlothian, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general),
Chip Scale Integration Secondary Focus

Aspirations: Start and develop a career as an ASIC Engineer

Class Comment: This course has allowed me to open and develop relationships and connections with people in-industry, and has given me an understanding of a project's life-cycle in that industry.

Payton Fallen Suffolk, Va.

Bachelor of Science in Computer Engineering
General CPE, Software Systems Secondary Focus

Aspirations: Be a part of the research and development of a new technology.

Class Comment: This course provided me with connections to people who are both knowledgable and experienced in the field of engineering. This has allowed me to not only experience what its like to be an engineer, but also gain essential skills to be successful in the engineering field.

CUSTOMER: MARIUSZ ORLOWSKI

Use & Abuse of Personal Information

LEFT TO RIGHT: Grant Hewett, Illa Rochez, Parker Chesney, Ameera Hossain, Madeline Renault | **SME:** Alan Michaels, Christopher Henshaw

CHALLENGE

To create a streamlined process and interface for account sign-ups while collecting data on the sign-up process. This process is part of a larger project which aims to detect where personal information travels through the internet.

Grant Hewett Baltimore, Md.

Bachelor of Science in Computer Engineering
Networking & Cyber Security

Aspirations: I aspire to work in the computer engineering field and make computers safer to use. My focus in Networking and Cybersecurity will help me to fulfill this goal.

Class Comment: This course was a great exercise in the engineering process. Working with a team on a major project helps prepare us as engineers for the real world.

Illa Rochez Warrenton, Va.

Bachelor of Science in Computer Engineering
Networking & Cyber Security

Aspirations: My aspiration is to help affect change in the way the private and public sector approach computer security. I hope to one day have the work I do protect innocent computer users from malicious hackers either through work on the blue team securing networks, or playing red team and helping companies find the weak points in their digital armor.

Class Comment: This course was a great experience. Our team was a chaotic group but we got work done and I am so proud of what we have accomplished. I learned a lot of things that I wasn't expecting to learn like PHP, and I got to revisit old friends from the beginning of my programming journey, like HTML and CSS.

Madeline Renault Chester, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I aspire to use the skills I have learned to make a positive impact in the world. I hope to continue learning throughout my entire career and be a part of innovation within software, cybersecurity, and machine learning. I would also like to be a supportive role model for future aspiring engineers.

Class Comment: This course provided valuable experience with a real-world application. I learned how to coordinate with my team to complete a project, from planning out requirements to completing the implementation. I was also exposed to new tools in web development that were not part of my computer engineering curriculum.

Ameera Hossain Sterling, Va.

Bachelor of Science in Computer Engineering
Networking & Cyber Security

Aspirations: My aspirations include filling the gap of women of color engineers within the industry and be the representation for other individuals who identify similarly. In terms of Cybersecurity, I want to work towards encouraging others—especially my peers—on the value of their data and how to protect it. Before my time reaches an end, I wish to also utilize my cinema minor to pursue my dreams of being involved in the production of a film that also represents individuals like myself.

Class Comment: The course provided me with a realistic example of what it's like working on an ongoing project with a team, customer, and deliverables. I gained skills in PHP, HTML, as well as the confidence to take on projects even with unfamiliarity. Overall I'm now open to taking on challenges knowing I have the capability to research and problem solve.

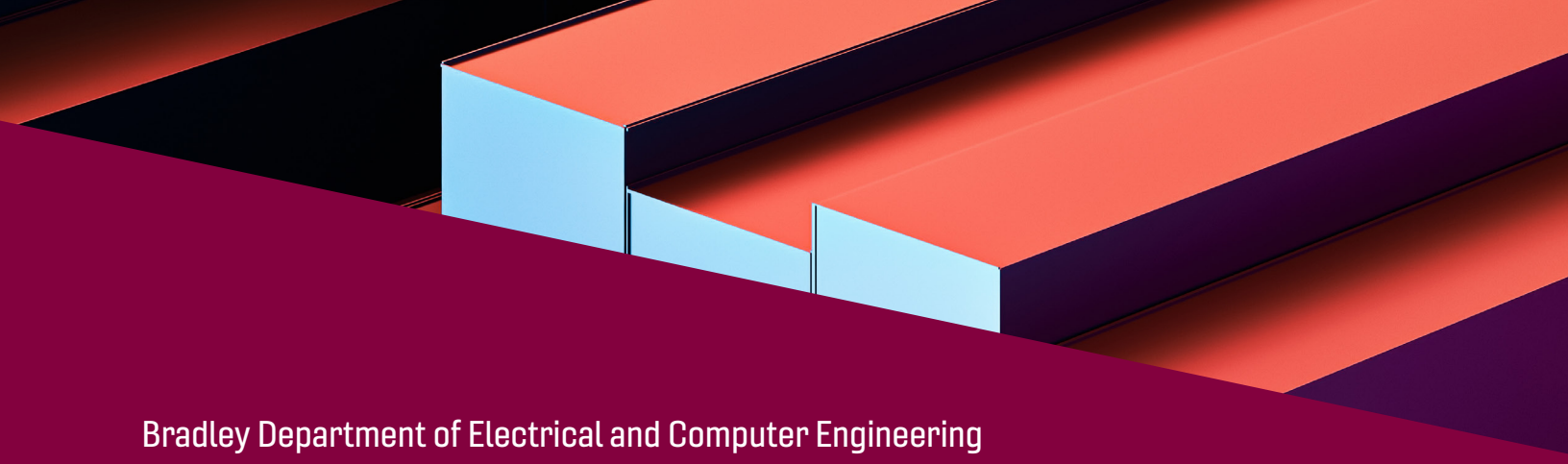
Parker Chesney Chesapeake, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My aspiration is to enjoy programming and solving difficult assignments in a team environment. I find hard problems to be the most enjoyable and worthwhile to solve and to do so with friends is one of my many highlights in this university.

Class Comment: This course gave me hands-on experience with LAMPS implementation of a website using PHP and javascript. Working on a team is also incredibly enjoyable and keeps me focused on the task at hand.

CUSTOMER: ALAN MICHAELS



Bradley Department of Electrical and Computer Engineering

Best in Course Recognition for Base Course performance

Spring 2022

ECE 1004 — Introduction to ECE Concepts

- Connor Adel
- Peter Costescu
- Thomas Lu
- Bryce Mooney

ECE 2024 — Circuits and Devices

- Dylan Christopher Green
- Jia Xue Kow

ECE 2214 — Physical Electronics

- Nick Merton
- Sam Zaveri

ECE 2514 — Computational Engineering

- Jia Xue Kow

ECE 2544 — Fundamentals of Digital Systems

- Evelyn Chua
- Dylan Christopher Green
- Jia Xue Kow
- Jivitesh Kukreja

ECE 2564 — Embedded Systems

- Gabriel Abernathy
- Will Bonner
- Caroline Elisabeth Larsen
- Sam Zaveri

ECE 2714 — Signals and Systems

- Atif Alam

ECE 2804 — Integrated Design Project

- Mason Lopez
- Rebecca Rainhart
- Rebecca Schuette
- Hayley Wisman

PROJECT CONTRIBUTOR ACKNOWLEDGEMENTS

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Luke Lester
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Kim Medley
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Donald Leber
for providing cleanroom access and training for students

Chelsey Seeber
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Bianca Norton and Virginia Tech Inn Staff
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Special thanks Ms. Amrita Chakraborty
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for being great teaching assistants in support of these 75 MDE students and others completed and in progress.

Sam Yakulis, Tom Drayer, and Mike Penzo
for supporting the MDE Expo as Panel Judges.

Toby Meadows, Mary Brewer, and Jeff Walling
for serving as track Masters of Ceremony during the Expo

PROJECT POSTERS

TRACK 1

Latham A

Mary Brewer
Master of Ceremony

Sam Yakulis
Judge

AI Multi-Sensor Fusion

Team Members: Gustavus de Andrade, Nathan Harvey, Matthew Hardmon
Mentor: Prof. Shelley Stover **Customer:** Anson Lam, Aerospace Corp
Subject Matter Expert: Prof. Nektaria Tryfona

The Motivation

Navigational systems are a key component to modern society and have immense significance across numerous industries. Heavy reliance is placed upon accurate and resilient PNT (Position, Navigation, Time) applications within the civilian sector as well as the armed forces. By innovating a solution that fuses GPS and IMU (Inertial Measurement Unit) data, the outcome has the likely potential for increased performance compared to the individual components.

Fig 1. Visual representation of GPS and IMU performance as individual components compared to performance utilizing fused data

The Mission

The overarching goal was to develop a machine learning model that employed supervised learning techniques in order to accurately output the true position given GPS and IMU data as inputs, emulating the function of a Kalman Filter. By incorporating GPS and IMU data, the solution should exceed the accuracy of the individual component inputs. Thus, there were two clear objectives:

- Innovate a machine learning model that exceeds the raw GPS sensor readings in terms of accuracy
- Innovate a machine learning model that meets or outperforms a standard Kalman Filter implementation in terms of accuracy

The Dataset

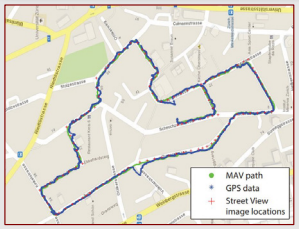


Fig 2. The Zurich Urban Micro Aerial Vehicle Dataset

The Zurich Urban Micro Aerial Vehicle Dataset was the world's first dataset recorded on-board a camera equipped Micro Aerial Vehicle (MAV) in an urban environment. The dataset is comprised of various features including:

time-synchronized high resolution images, ground level Google-street-view images, GPS readings, and IMU readings. The image data allowed for the MAV ground truth positions to be determined which was essential data when the objective is positional accuracy.

The recorded path length of two kilometers is divided into time synchronized .csv files for each sensor. This feature provided convenient conjunction of data that enhanced output potential.

Design & Implementation

A data augmentation pipeline was created with the purpose of preventing overfitting. The known ground truth values from the Zurich dataset were passed in and transformed into a new dataset by applying transformations such as offsets and rotations in space and then applying noise to simulate sensor inaccuracy.

Raw Data → **Transformations** → **Calculate IMU Data** → **Apply Noise**

Fig 3. Data Augmentation Pipeline

Recurrent Neural Networks (RNN) were the primary consideration for machine learning model designs due to their capacity for memory. This typically results in better performance for time series analysis and forecasting which is applicable to the mission.

GRU and LSTM models were the selected machine learning model designs. Steps to build the functioning models included data augmentation and data preprocessing. Logging essential information such as parameters, hyperparameters, model output plots, as well as training, testing, and validation metrics, was achieved for every program execution by employing the online resource Weights and Biases, wandb.ai.

Training & Tuning

Hyperparameter Evaluation

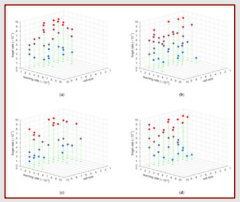


Fig 4. Hyperparameter evaluation for position estimation

Training & Validation Losses

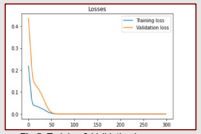


Fig 5. Training & Validation losses visualized

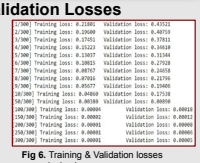


Fig 6. Training & Validation losses numerical values

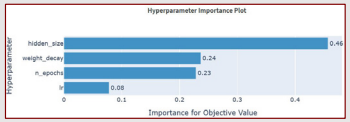


Fig 7. Evaluation of significance between different hyperparameters from Weights and Biases

Test Results

Fig 8. Model output when training on 80% of the one augmented dataset and attempting to predict the final 20% of the augmented dataset

Fig 9. Model output when training on 7 augmented datasets and attempting to predict the final 2 independent augmented datasets

Analysis & Conclusion

Analysis was conducted through comparison of model output accuracy. Utilizing Weights and Biases, plotted outputs and key metrics were compared with each program execution. Furthermore, each model was also plotted against the ground truth data and outliers are visualized by employing the outlier detection model. Post analyzation, it was concluded that the LSTM model had a higher performance than GRU.

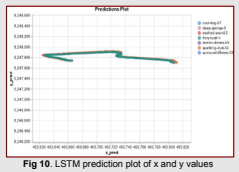


Fig 10. LSTM prediction plot of x and y values

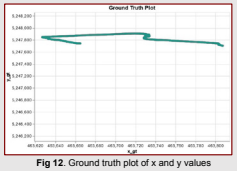


Fig 12. Ground truth plot of x and y values

LSTM Predictions Metrics:

Format = (x-axis, y-axis)

- Mean Absolute Error = (0.4389, 0.927)
- Root Mean Squared Error = (0.5505, 1.14)
- R^2 = (0.9999, 0.9996)

Fig 11. LSTM prediction metric values retrieved from Weights and Biases

Raw GPS Metrics:

Format = (x-axis, y-axis)

- Mean Absolute Error = (0.4188, 0.4222)
- Root Mean Squared Error = (0.5231, 0.5287)
- R^2 = (1, 1)

Fig 13. Raw GPS metric values retrieved from Weights and Biases

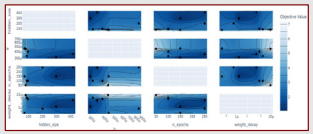


Fig 14. Contour plot of hyperparameters against each other from one execution. Color coded by the objective value (sum of mean absolute error)

Fig 15. Outlier Detection Model output

Further Research

Potential extensions of the project:

1. Flight plans for aerial vehicles involving complex movements in three dimensions could be integrated to produce predictive models that can estimate height, as well as potentially be more accurate if given a larger quantity of angular velocity information.

2. Integrating with a standard Kalman Filter that is intended for error correction could produce higher quality results. A simple experiment could involve averaging their disparate predictions. A thorough systemic integration could result in the model producing a Kalman Filter gain or error covariance matrix instead of a final prediction.

Acknowledgements

We thank the following people for their generous support and assistance.

- Shelley Stover (mentor)
- Anson Lam (customer point of contact)
- Nektaria Tryfona (subject matter expert)
- Shihua Sun (consultant)

Satellite Navigation Algorithm

Team: Jeremy Bruce, Matthew McLaughlin, Aaron Yang, Grant Hutchins
Sponsor: Dr. John A. Janeski, The Aerospace Corporation
Subject Matter Expert: Dr. Gregory D. Earle, Virginia Tech

Introduction

Satellites generally rely on the Global Navigation Satellite System (GNSS) to provide position, navigation, and timing (PNT) data. Our objective is to design a small-satellite navigation sensor capable of supplying PNT data when GNSS interference occurs.

Key Requirements

- GNSS signal may not be used
- Utilize an IMU as well as other sensors
- Unit must fit within a 1U (10x10x10cm) volume
- Unit mass must be less than 1.5kg
- Output data rate must be >200 Hz
- Minimum propagation time of 10 minutes

Concept of Operations

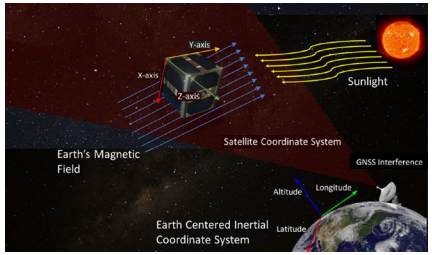
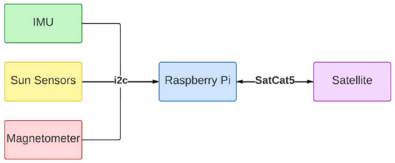


Diagram of the navigation operation of the sensors.

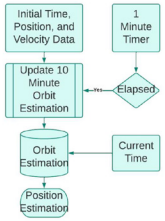
Approach



Flow chart of the full navigation sensor system hardware

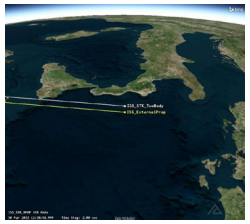
The prototype designed by the previous team consists of 3 types of sensors: IMU, magnetometer, and Sun sensors. Data from all sensors are inputted to the Raspberry Pi via the I2C communications protocol and blended into a single PNT solution. This is then sent to the satellite through the SATCAT5 communications protocol.

Orbit Propagation



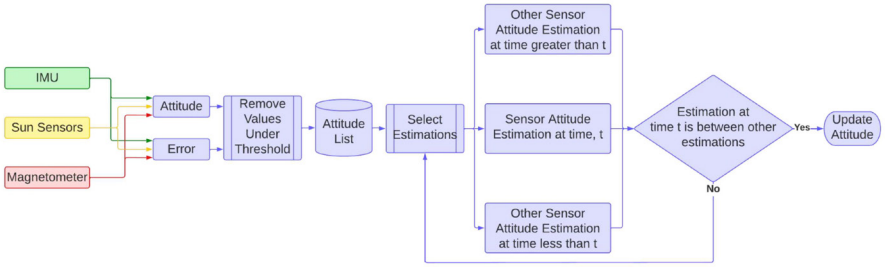
Flow chart of orbit propagation algorithm

- Orbit is predicted for the conditions of the spacecraft at the time of GNSS signal loss
  - Position, velocity, time converted to an inertial frame
  - Sample orbit mirrors ISS orbit of ~422 km
- Prediction is made for the estimated duration of GNSS blackout—approximately 10 min
- Orbital perturbations considered:
  - Drag—NRLMSISE00 model
  - Gravity—EGM2008 model
  - Solar Radiation Pressure—Ephemeris



Sample orbit propagation result

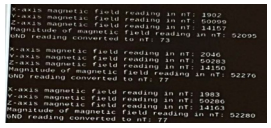
Sensor Fusion



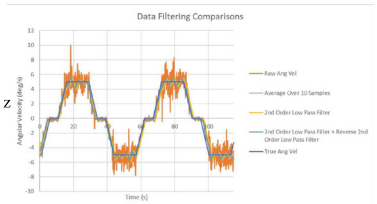
Three sensor subsystems input their data readings and error margins to the sensor fusion algorithm. The Sensor fusion algorithm evaluates the data, immediately removing any reading that falls below the validation threshold. Attitude estimates are calculated based on the sensor readings and then compared to find lower and upper bounding measurements. The estimation falling between the lower and upper bounding estimates is selected for use in updating the spacecraft attitude.

Hardware (Sensors)

- Inertial Measurement Unit (IMU)
  - Acceleration and angular velocity data
- Magnetometer
  - Earth's magnetic field magnitude on the x, y, and z axes
- Sun sensors
  - Five sun sensors used to create an 8x8 heat map



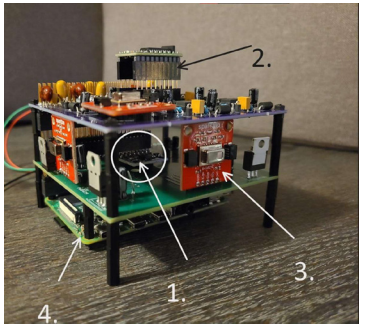
HMC2003



GY-521 MPU6050 IMU

Sun Sensor

Hardware Result



Full hardware assembly

1. IMU
2. Magnetometer
3. 1x Sun Sensor
4. Raspberry Pi 4
   - PCB is placed on top level
   - Middle PCB is dedicated to power distribution

Conclusion

Completed hardware goals:
- Sensor noise reduction
- Sensor characterization models
- Sensor testing in adverse environments
- Full system testing

Completed software goals:
- Reference frame rotation
- Sensor fusion algorithm
- Developed working algorithm for cohesive system data acquisition

Overall, most of the system design and testing has been completed, but there are more steps required to achieve full functionality. Once full functionality has been achieved, extensive testing should be performed to characterize the performance of the navigation sensor.

Acknowledgments

Sat Nav would like to extend a special thanks to Dr. Gregory Earle, Dr. Samantha Kenyon, Dr. John Janeski, Mr. Alex Utter, Dr. Stephen Spry, Dr. Howard Ge, Dr. Scott Ransbottom, and Professor Toby Meadows for their invaluable advice and support throughout the duration of this project.

Helium Mining Prediction Algorithm

Ken Atta-Boakye Jr., Christopher Forgash, Noah Meine, & Yingqi Pei
Sponsor: Andrew Millard, Jump Crypto
Subject Matter Expert: Dr. Leonard Smith, Virginia Tech

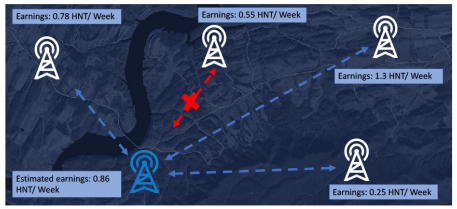
Background

The **Helium Blockchain** is a wireless network that provides internet access to **Internet of Things devices.** Hotspots provide the network's coverage and are rewarded with a publicly tradeable **Cryptocurrency** called **Helium Tokens (HNT)**. The goal of this project is to **predict the HNT mining rewards of a proposed Hotspot based on location and antenna configuration.**

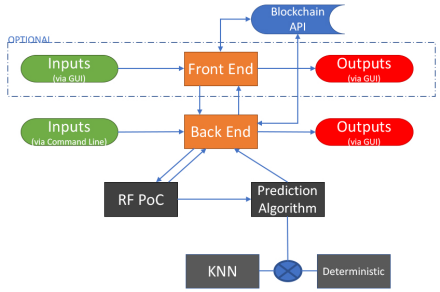
Major Requirements

- Predicts weekly HNT mining rewards along with a confidence interval
- Determines Hotspot Coverage via Radio Frequency (RF) Analysis with Splat
- Provides visual feedback and interaction via a Graphical User Interface (GUI)

Concept

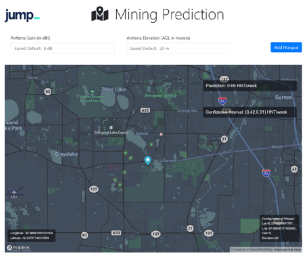


Approach



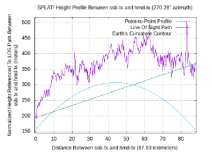
User Web Interface

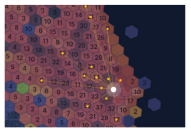
- Allows a user to explore projected HNT rewards as a function of:
  - Location
  - Antenna gain
  - Antenna height above ground
- Shows the number of nearby hotspots and their status
- Allows the user to see a predicted confidence interval for mining rewards
- Saves user data and past simulations in a MongoDB database
- Future work to make recommendations on optimal placement



Proof of Coverage

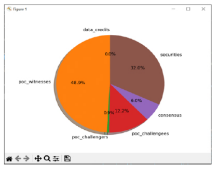
- Aim is to determine which hotspots can be seen "witnessed", or can see us "beaconed"
- RF path loss models predict which hotspots will create valid proof of coverage links
  - NASA's public elevation data is used to model irregular terrain
- Valid links must meet signal-to-noise ratio (SNR) and received signal strength indicator (RSSI) thresholds
- Uses Uber's h3 hexagon projections for proximity limits and rewards scaling
- Users can see which hotspots they can communicate with and how strong the signal is

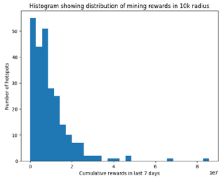


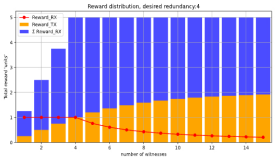


Predicting Rewards

- Valid links are used to determine the projected number of beacons and witnesses
  - Historical data is used to see trends and make predictions
- Local activity is projected into the future to compute an average mining reward per week
- Projections are compared to local geographic distribution for error analysis







Results

- In a sample of 50 randomly selected hotspots:
  - RF modelling correctly predicted 63% of bi-directional links and 81% of witnesses
- In another random sample of 50 hotspots:
  - 88% of actual mining rewards fell within the predicted confidence interval
  - Average error was 0.22 HNT/week
  - Average uncertainty in confidence interval was 1.88 HNT/week

Conclusion

Completed Work:

- Created GUI for network analysis
- Determined coverage of nearby nodes
- Prediction of confidence interval of mining reward from proposed node
- Performed validation on randomly selected sets of hotspots
- Conducted analysis of major error sources

Future Work:

- Further validation of mining rewards
- Use network data transfer as system input
- Investigate use of high-resolution terrain data
- Change prediction systems as blockchain evolves

The major system requirements have been completed. Users are able to perform investigative analysis using the web interface or perform bulk simulation via the command line. To improve this project, future work should include increasing validation sample size and investigating the use of higher resolution terrain data.

Acknowledgements

- **Andrew Millard & Jump Crypto**, our Customer, for consistent and constructive feedback
- **Dr. Leonard Smith**, our Subject Matter Expert, for his expertise knowledge in Machine Learning and Statistical Analysis
- **Dr. Scott Ransbottom**, our Mentor, for his professional guidance and assistance over the course of this project

Composite Structure Damage Detection With Machine Learning

Team: Shashank Vasanth, Kien Tran, Kevin Vo
Sponsor: Steven Kestler, Charlene Hu, Jaynesh Patel, Saul Montano, Collins Aerospace
SME: Dong Ha, Zhuqing Zhao Mentor: Shelley Stover

Project Objective

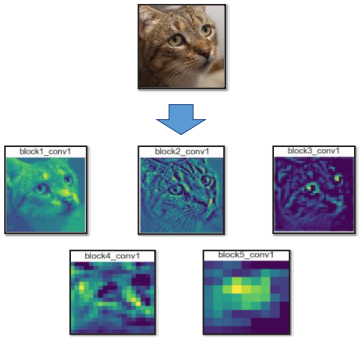
To localize and characterize damage on a composite structure

Background

A convolutional neural network (CNN) finds patterns and trends in images to discern patterns objects, faces, and scenes.

Feature extraction:
- Shallower layers extract detailed texture-like features
- Deeper layers extract the high-level features
- Extracted and condensed information for classification or other tasks (eg. instance segmentation)

Instance Segmentation is used to locate, segment and classify one or multiple objects within an image in this project.



Challenges

- Overfitting
- High computational cost
- Disproportionate spread of labels within the dataset

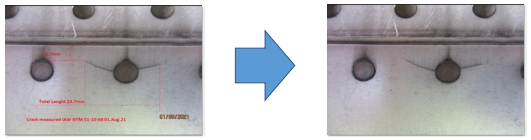
Preparing Dataset

The model learned from the image and label pairs. The labels were converted into masks and stored in a .json file.

Preprocessing

We cleaned the dataset to facilitate accurate and effective training.

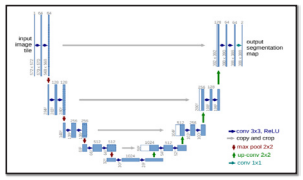
- Removing misleading labels
- Normalizing and cropping the images to the same size



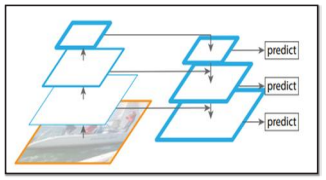
Architecture

U-Net
- U-shaped encoder-decoder network architecture
- Four encoder blocks and four decoder blocks are connected via a bridge

Feature Pyramid Network (FPN)
- Input a single-scale image of an arbitrary size, and output proportionally sized feature maps at multiple levels



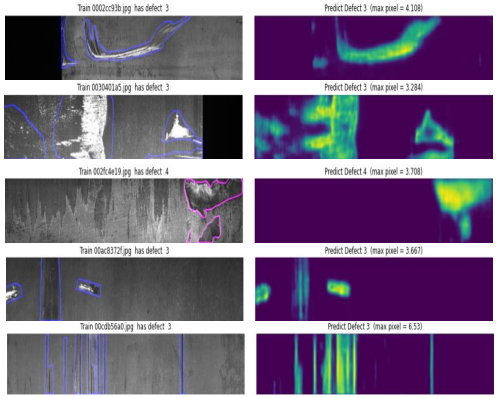
U-net



FPN

Test results

Model predictions that indicate the damage location and types



Future works

Performance:
- Our model achieved a 90% dice coefficient on validation set.
- In future, augment dataset to address imbalanced distribution, and experiment with more loss functions.

Efficiency:
- Long training time takes about 30 to 120 epochs. Each epoch takes about 105 seconds.
- In Future, apply various techniques, such as separable convolution.

References

Dataset:
"Severstal: Steel Defect Detection," Kaggle. [Online]. Available: https://www.kaggle.com/c/severstal-steel-defect-detection
Labeling annotation tool:
Supervisely - Dashboard. [Online]. Available: https://app.supervise.ly/login?redirect=%252Fprojects
U-Net:
Ronneberger, O.; Fischer, P.; and Brox, T. 2015b. Convolutional Networks for Biomedical Image Segmentation.
FPN:
Lin, T.-Y.; Doll´ar, P.; Girshick, R.; He, K.; Hariharan, B.; and Belongie, S. 2016. Feature Pyramid Networks for Object Detection.

INTERACTIVE ECE DEGREE PLANNER

Team members: Lauren Anderson, Wejdan Alnofeiy, Joseph Petruzziello, Chenyi Wang, Runchen Zhu
Customers: Mary Brewer, Nicole Gholston **SME:** John Ghra **Mentor:** Scot Ransbottom

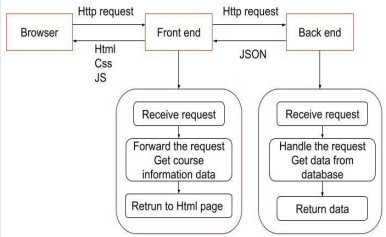
Purpose

The goal of this project is to create a place where students can find all of the necessary information for a major and validate their "plan of study" against the graduation requirement, and advisors can digitally update the requirements for each course and major.

Key Requirements

1. Create a functional website with multiple interfaces
   a. Student page where students can plan and validate their degree
   b. Advisor page where advisors can add, update, and delete courses, majors, and degrees.
2. User-friendly interface for clients to use.
3. Dynamic programming so the project is expandable in the future.
4. Easy set-up and instructions for end users.

Technical Design

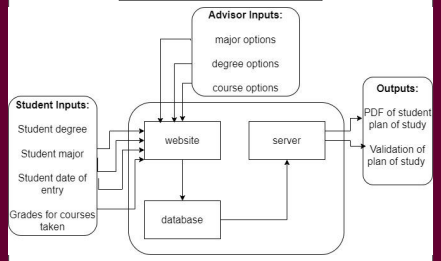


The project is based on the front-end and back-end separation development model. The front end is developed using the Vue framework and The back end is developed using the Django framework and MySQL database.

Front end
Front end is responsible for data display and user interaction, and the front-end HTML page is responsible for data interaction by calling the back-end interface.

Back end
Back end is responsible for providing data processing interface. The front end and back end interact with data in JSON format.

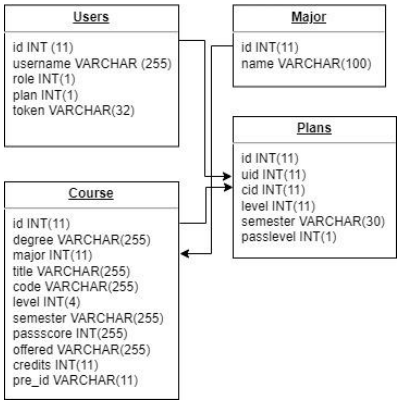
Logical Architecture



Inputs: Students will enter their degree, major, date of entry, and any grades for courses they've taken in the student interface. Advisors will input all majors, degrees, and courses into their interface.

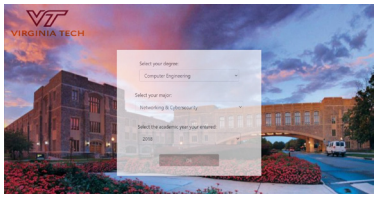
Outputs: Students will be able to verify their plan of study is correct, and generate a pdf to send their plan to their advisor.

Database Design

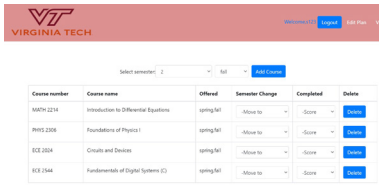


Each student has data to connect them to their plan of study, which includes course information and major information based of of the data they inputted into the student interface upon login. Users with advisor roles can add, modify, and delete courses and majors.

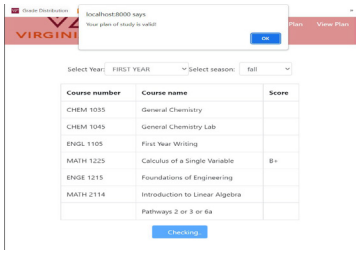
Front End Design



Degree Page: allows students to select their degree, major, and the year they entered the university.



Edit Plan Page: allows the student to edit their plan of study by choosing which semester they want to edit and then moving the course to a new semester and inputting grades for any courses that have been taken.



Verify Plan Page: This page is a part of the student view and allows students to view their plan of study, verify that it is valid, and save it as a pdf to send to their advisor.

Conclusion

The delivered product allows users to log in as either a student or an advisor with their PIDs.

- **Students:**
  - Able to make a study plan based on their major and first academic year at VT
  - Able to validate the plan against the graduation requirement
- **Advisors:**
  - Able to keep track of the curriculum
  - Able to add, update, and delete courses and majors

All the changes made by the users can be successfully synchronized to the database.

Future Plan

In addition to the currently delivered functionalities, there are more features that need to be added for advisors and students.

- **Pathway:**
  Allow students to browse and pick their desired pathway and verify their plan based on their choices.
- **Transfer credits and courses:**
  Able to recognize and validate the plan that includes transfer credits and courses.
- **Add years:**
  Allows students to make plans for more than four years
- **Link to the ECE department:**
  When this tool is fully developed, it will be eventually linked to the ECE department website instead of being separate
- **And many more!**

Acknowledgements

The ECE planner team would like to thank the following people their guidance and support throughout the project:

- Mary Brewer & Nicole Gholston, Customers
- John Ghra, SME
- Scot Ransbottom, Mentor

HUME CENTER FOR NATIONAL SECURITY AND TECHNOLOGY
VIRGINIA TECH

Use and Abuse of Personal Information

Parker Chesney, Grant Hewett, Ameera Hossain, Madeline Renault, Illa Rochez

Sponsor & Subject Matter Expert: Alan Michaels

VIRGINIA TECH

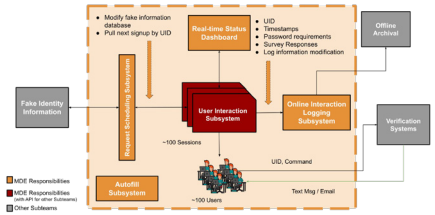
Background

System At a Glance

- The Use and Abuse of Personal Information is an ongoing research project led by Dr. Alan Michaels at the Hume Center
- The main goal of the project is to sign up accounts to various websites and track where the information goes and how it's used
- There will be 100,000 fake identities with computer generated information (name, email, phone number, website etc.) that will be signed up to a online service
- Relevant information to each account (emails, phone calls, text messages, etc.) will be collected and analyzed by future teams to study the transfer of information across the internet.
- Our project is to create a subsystem for this overarching project that streamlines the sign-up process for users and to collect information relevant to the sign up process (information used, password requirements, etc.)

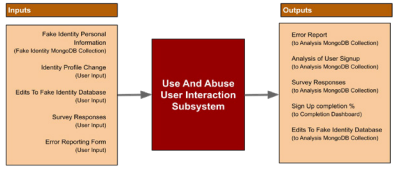
Objectives

- Create a web-based user interface that is capable of allowing 100+ users to simultaneously sign up to newsletters, online accounts, and social media with more ease via the following features:
  - Easy access to the data related to one singular Identity at a time
  - A copy feature
  - An edit feature for only the associated password and URL
  - Survey System that records user responses to questions relevant to the sign-up process
- Backend processes to ensure a smoother sign-up process
  - Logging system to track additional information related to the sign-up process and the completion of each signup
  - Security measures to prevent tracking of identity information



Entire Use & Abuse System, and assigned MDE subsystems

User Interaction Subsystem

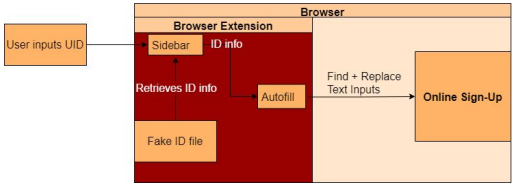


Input-Output Diagram

Signup Page From Website

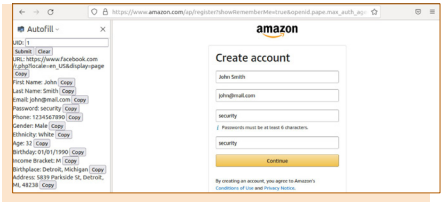
- a scalable *web-based* interface was developed that can display the pre-generated fake identity information from any device.
- Several copy and edit buttons were implemented that interact with the logging subsystem and fake ID database to store any changes to the data.
- Pop-up windows that block unwanted user interaction with other page elements (ie. while editing password/URL information)
- Styling that promotes user friendliness including following web development standards for button coloration and organized data columns
- Survey that records user inputs related to information usage, password requirements, and other relevant items.

Autofill Subsystem



Autofill Block Diagram

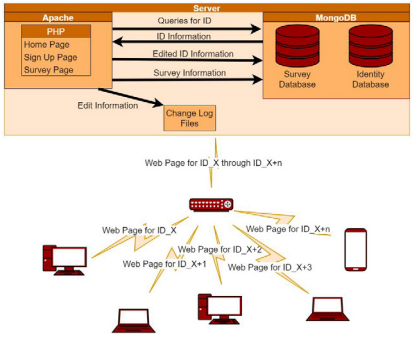
- Implemented to streamline process of signing up for a large number of accounts - no need to enter text manually for every field
- No interaction with web server to prevent fingerprinting and tracking
- IDs stored locally in JSON file within extension
- Automatically fills fields in online sign-ups
- Optional for users - installed as a Firefox browser extension
- Appears as sidebar on browser with all information displayed
- User enters UID (given from server) to get correct fake ID
- Function to clear browser cache between sign-ups
- Copy button for cases in which autofill fails



Example Sign-Up with Extension Installed

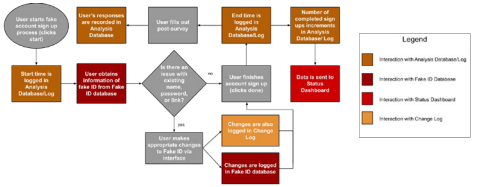
Server Development & Request Scheduling System

- Our website was create with a LAMP (Linux, Apache2, MongoDB, & PHP) stack
  - Linux is the operating system, Apache2 is the web server, MongoDB is the storage database, and PHP is the language used to interact with the database



System Interactions Diagram

- This stack was initially setup in a virtual machine for testing, then migrated to a Raspberry Pi
- We developed a request system that would give the user a new identity in sequential order without having two users getting the same identity
- Any edits made to the information in the identities will be saved on a local log file for later analysis



Flow of Online Sign-up

Challenges & Future Work

- **Challenge:** Learning new concepts such as database management via MongoDB and new languages like PHP was laborious
- **Challenge:** Overall how to build a website for a local server was a large learning curve for the entire team
- **Future work:** Server hardware can be scaled up to be able to handle a larger number of users signing up
- **Future Work:** Outside subsystems (phone and email verification) could be integrated to function with the User Interaction Subsystem

TRACK 2

Latham B

Jeff Walling
Master of Ceremony

Tom Drayer
Judge

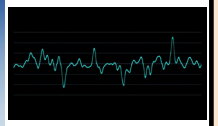
Coral Jam Machine Learning

Sean Pack, Luc Phan, Jacob Lowe
Sponsor: Adam Belhouchat, The Aerospace Corporation
Mentor: Shelley Stover, Virginia Tech
Subject Matter Expert: Nektaria Tryfona, Virginia Tech

Background

Signal Jamming is an important topic and aspect that can affect many if applied to day-to-day life. Signal Jamming can specifically target structures or devices such as radio towers, cell phone towers, and satellite signals. Any of these structures or devices that have their signal data tampered with could completely halt daily commutes and communication as we know it. For example, if an air traffic control tower had its signals and radio communications jammed by third parties, pilots would not be able to contact air traffic control correctly. These types of signals must stay unaltered and consistent, free of noise.

With Machine Learning, models exist that can learn to take corrupted signal data and pass it through a model so that uncorrupted signal data will be the output. These devices and models must be compatible with smaller sizes, weights, and power devices. Therefore, integrated affordably inside existing structures and devices.

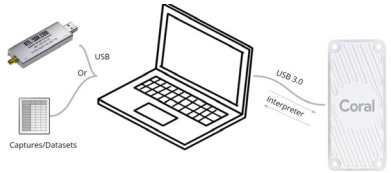


Objectives

Our Objective is to take Machine Learning models and evaluate how they can be converted into smaller models that can be run on low Size, Weight, and Power (SWAP) devices. The models are developed in TensorFlow and to be on smaller devices must be converted to work with Tensorflow Lite, a more lightweight version of the program.

TensorFlow → TensorFlow Lite

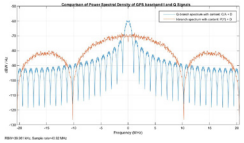
System Overview



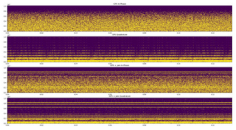
Jammed GPS Signal Dataset

MATLAB was used to generate several datasets via the radar toolbox, signal processing toolbox, and Satellite Communications Toolbox. Each of the datasets have a different purpose. First, two datasets exist to simulate chirp and continuous wave jammers. These signals are simply added together. The second is a more realistic dataset where free space calculations are used. Using the radar toolbox, realistic but randomized distances are used for the jammer and satellite in relation to the receiver.

Simulated GPS Power Density



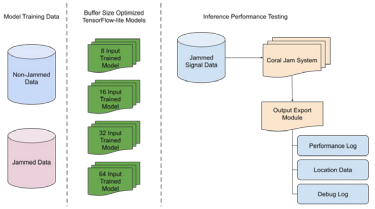
Quantized Spectrogram of GPS Dataset



Model Training and Lite Conversion

The Model training was done via a Jupyter Notebook, where a subset of the data was used for training, then compared to the testing data. Then the model learns from the data and adjusts to create a more accurate prediction. After repeating this process for a specified amount of iterations or after an accuracy threshold is reached, the model stops and outputs a plot that shows the predictions versus the actual data.

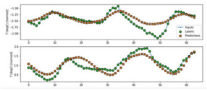
The conversion of the model was done via TensorFlow's own Lite converter. The first step of the process was to call the converter method to shrink the model in size. Afterwards, the model can be called via a TensorFlow interpreter. The interpreter is like running the model via the command prompt. The interpreted TensorFlow lite model functions similarly to the full scale model, except it can only use the built in interpreter functions. The lite model can then be delegated to be run on the Coral TPU for faster computations.



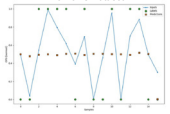
Initial Model Design

When applied to general time series data, our FCNN model had an accuracy with a range of 71% to 87%. With GPS signal data the FCNN model was only capable of 50% accuracy, basically guessing.

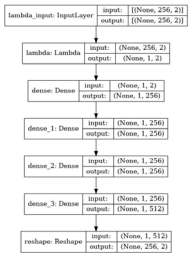
Model Predictions when Trained on General Time Series Data



Model Predictions when Trained on GPS Dataset



Fully Connected Neural Network Diagram

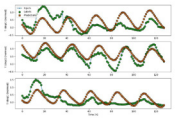


Model Evaluation and Cross Validation

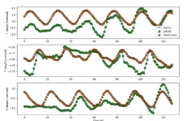
While researching alternatives to the FCNN Model, the TensorFlow Lite Model Conversion pipeline was developed. Performance comparisons between TensorFlow and TensorFlow Lite were benchmarked on the generalized FCNN Model.

The TensorFlow Lite model performed similarly to the FCNN model when examining the plots. However, when comparing the two models numerically, the thing that stood out between the two models was the drastic difference in validation loss. This was due to how the loss was computed. TensorFlow has a built in loss functions that was set to compute loss using mean squared error. However, the lite model does not have the luxury of calling on the mean squared error function. Thus, the hand calculation shows a vastly different value. The other values show similar results, however.

Model



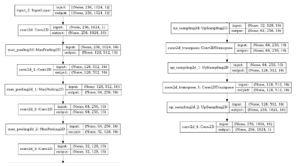
TF lite



Moving to Convolutional Denoising AutoEncoder (CDAE) Model

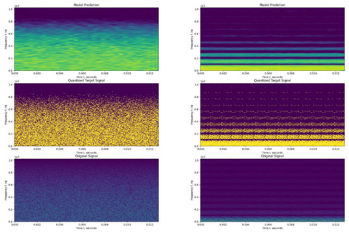
After attempts to solve underfitting when applying the FCNN to the GPS dataset, new model types were explored. CDAE's showed promise in denoising and reconstructing signals.

Convolutional Denoising Autoencoder Diagram



CDAE Model Evaluation

At this time, the model is being assessed by comparing the Short Time Time Fourier Transform of the GPS dataset with the output of the model. Initial results are promising for this model type's ability to reconstruct the GPS signal when jammed.



Conclusions

In conclusion, the lite model conversion pipeline was successfully created and tested. The CDAE model shows promising results. However, it was not fully implemented in time. For the future, further optimization and integration of the CDAE model should provide a possible solution to the proposed problem.

Acknowledgements

The Coral Jam team would like to thank the Sponsor for giving advice on model performance and testing and for supplying the Google Coral TPU. The team would also like to thank Nektaria Tryfona for access to resources such as outside datasets. Finally, the team would like to thank Shelley Stover for her continued support of the team.

Space Circuit Design and Testing

Sponsor: Randy Spicer & Julianna Neumann
SME: Dr. Jeffrey Walling **Mentor:** Prof. Kenneth Schulz
Jean-Luc DeRieux, Brandon Reasoner, Nicola Belfiore, and Ishaan Bhambra

Background

Low Earth Orbit (LEO) satellites are important for critical applications such as communications, GPS, military reconnaissance, weather forecasting and more. In order for them to complete these tasks, they require proper orientation relative to Earth's surface.

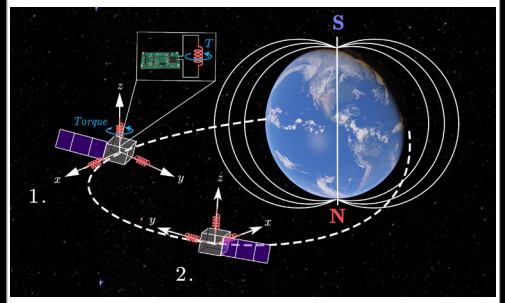


Fig.1 - Concept of Operation [1]

The main way they align themselves relative to Earth's surface is by generating momentum using a magnetorquer. These devices produce a magnetic field which works against Earth's magnetic field to create torque. They are lightweight, use no propellent, and have the ability to use solar energy as its power source.

As seen in Fig.1 stage 1 represents the activation of the magnetorquer and stage 2 represents the LEO satellite being rotated fully after the magnetorquer has produced its magnetic field to align itself relative to Earth's surface. As seen in the image inset, the magnetorquer driver circuit we created will be used to generate the torque associated with the 3-axis magnetorquers.

Problem Statement

- Control a magnetorquer in two directions at provided 5-32V range
- Support high inductance and back EMF
- Design hardware with radiation mitigation techniques
- Control driver with microcontroller (MCU) using frequency, duty cycle, and magnetorquer polarity
- Implement software utilizing radiation mitigation techniques

Objectives

- The circuit must be able support a magnetorquer that can generate 1000 A/m^2
- Functional in -20°C to 80°C environment
- Radiation hardened and/or mitigated
- The circuit should be compact 3" x 1"
- The circuit output must be able to change polarity

System Design

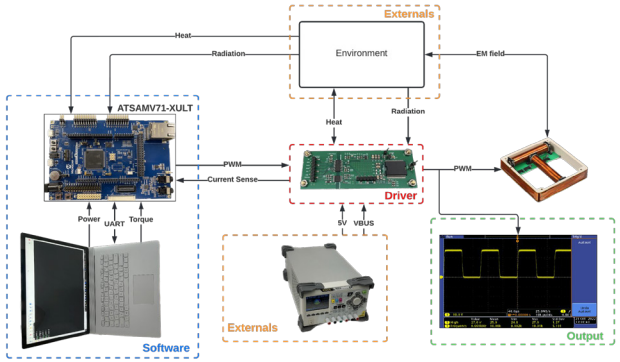


Fig.2 - System Overview [2]

Software

- Configurable PWM output: duty cycle, frequency, and magnetorquer polarity
- UART communication with PC for user I/O
  - Input commands to enable/disable PWM, configure duty cycle, swap polarity, and output current status
- Radiation mitigation:
  - Parity bit for all variables in memory
  - Redundant memory: duplicated variables with 1-fault tolerance
    - Finds and utilizes duplicates on single fault
  - Watchdog timer (resets entire system if stuck)
- Researched Source: NASA

Driver:

- Radiation Mitigation
  - Circuit design can withstand gate leakage failures from ion impacts
  - Isolation protects µController from partial failures / space weather events
- Thermal Considerations
  - "Heavy copper" increased thermal mass and reduces thermal shock
  - Large thermal pads for the hottest ICs maximizes heat dissipation
  - Thermal vias allow additional heat dissipation
- Circuit is "voltage agnostic" and can take an input of 5-28V
- Has current shoot-through protection
- Circuit can be driven in 2-directions allowing bi-directional actuation
- Provides current feedback to control software
  - Important because actuation force is directly proportional to load current

Externals:

- VBUS representing craft supply voltage of 5-28V
- Low Earth Orbit environmental conditions of high ambient temperature and radiation

Output:

- Configurable load square wave within 5-28V

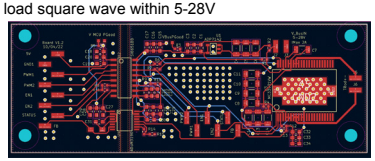
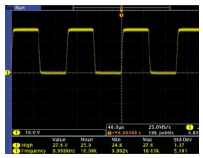


Fig.3 - Final PCB Layout of V1.2

Results

In the testing stage of our circuit we performed multiple tests to verify that our circuit functions as intended and met all of the criteria and requirements.

Some of the actual values were slightly off from the ideal values. With further time we believe we could get more ideal values.



Metric	Priority	Units	Marginal Value	Ideal or Target Value	Actual Value
System Steady State Operating Temperature in Vacuum	4	°C	-20 - +80°C	-20 - +80°C	*Test is still being planned
System Input Voltage Acceptance	4	V	5-32V	5-32V	5-28V
Minimum Dipole Moment	5	A*m^2	10 Am^2	1000Am^2	1000Am^2 *Analytically calculated
System Length	2	in	3 in	2 in	3 *Measured PCB from max comp. to min. comp. Complete system length. ~3.48"
System Width	2	in	1 in	1 in	1 *Measured PCB from max comp. to min. comp. Complete system width. ~1.22"
System Thickness	1	in	½ in	⅛ in	0.38
# of PCB Layers	1	#	4	2	4
PWM Duty Cycle	4	%	0%→50%	0%→50%	5%→95%

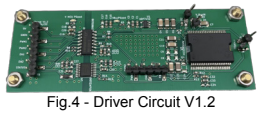


Fig.4 - Driver Circuit V1.2

Acknowledgements

We would like to thank Julianna Neumann and Randy Spicer from Northrop Grumman, Prof. Schulz, Dr. Ransbottom, Dr. Walling, Space@VT, and Matthew Sclafani (Virginia Tech) for their support and help during this Major Design Experience in the ECE department at Virginia Tech.

References

[1] Fig.1 Picture of Earth from Google Earth Studio. https://earth.google.com/studio/ [Accessed: 03-Nov-2022].
[2] Fig.2 "CubeSat magnetorquer SatBus MTQ," *NanoAvionics*, 11-Jan-2022. [Online]. Available: https://nanoavionics.com/cubesat-components/cubesat-magnetorquer-satbus-mtq/. [Accessed: 04-Nov-2022].

Stabilizing Helicopter Sling Loads

David Reineke, Luyi Tang, Duy Nguyen

VIRGINIA TECH

BREEZE EASTERN

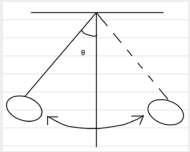
Background

Medical rescue [1]

Helicopter payloads for medical evacuation are difficult to stabilize once they begin to swing. As a result of forces during lifting, the payload will begin to swing back and forth.
A recent study has shown that by precisely varying the length of the payload line, stabilization can be achieved [1].

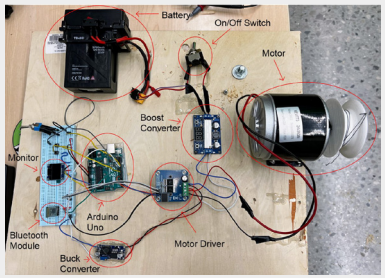
[1] A. Morock, A. Arena, M. Lanzerotti, T. Aldhizer, J. Capps, and W.Lacarbonara, "Variable length sling load hoisting control method."

Requirements

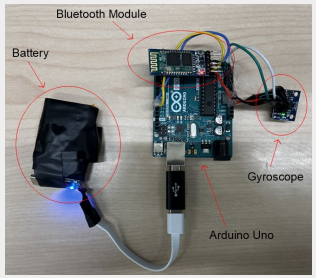


- Stabilize a swinging payload at the base of a pendulum by varying the length of the line
- Implement the provided algorithm that describes how to pull up at the ends and lower at the middle of the swing
- Demonstrate the success of the stabiliztion algorithm by analyzing the results of the testing

Hardware Implementation

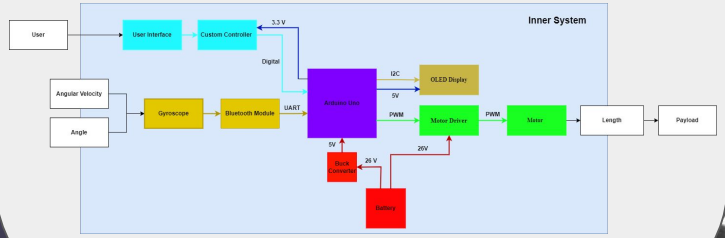


Device Main Body



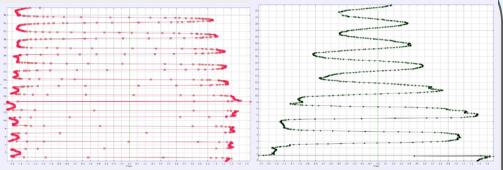
Payload

The hardware implementation uses a motor to vary the length of the line, a gyroscope to measure the change in the angle over time, two bluetooth modules to send and receive data, and a display to show the current angle. Finally, with push buttons and toggle switches for direct user input, the hardware was kept simple.



Architecture Design

Testing Results



Control Swing **Stabilized Swing**

- The graphs depict the relationship between angle in radians (x-axis) and the time in seconds (y-axis)
- It can be clearly seen that the stabilized swing took less time to trend toward a stabilized point than the control

Accomplishments

- Successfully stabilized the payload
- Designed the stabilization device
- Implemented the stabilization algorithm
- Demonstrated that by using the algorithm it takes less time to stabilize the payload when compared with a free swinging one

Acknowledgements

- Prof. Toby Meadows
- Dr. Mary Lanzerotti

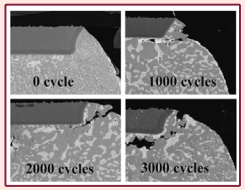
Video Demo

PHM PEC (Prognostic Health Monitoring of Power Electronic Converters)

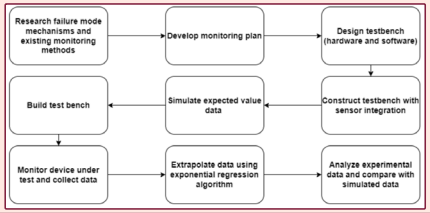
Sponsor: Debabrata Pal–Collins Aerospace
Subject Matter Experts: Shuxiang Yu, Narayan Rajagopal **Mentor:** Kenneth Schulz
Team: Kourosh T. Khoie, Corwin Warner, You Li, Luis Yon, Jeff Chambliss

Introduction

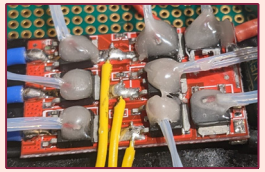
- Power Electronic Converters (PECs) need to be reliable. Component failure in PECs can be catastrophic (especially in aerospace applications).
- A Prognostic Health Monitor (PHM) can determine the remaining lifespan of PEC components so that proactive maintenance can be performed to prevent failure and downtime.

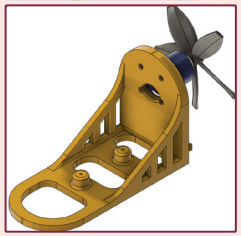


Process



System Development





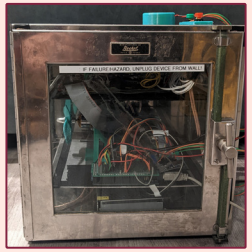
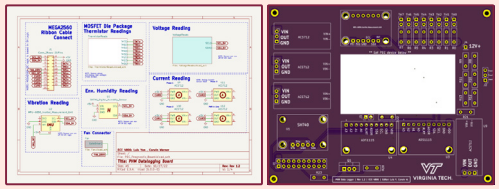


Figure 1.1, 1.2, 1.3, 1.4: Hobbypower ESC in original casing (top left), ESC with thermistors attached via thermal epoxy (top right), testbench core with fan (bottom left), test enclosure with the data logger and testbench inside (bottom right).

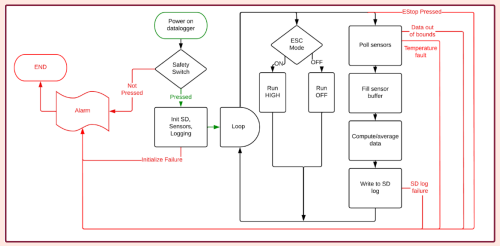
Circuit Design



Data Logger Unit (housed within the test enclosure)

- Houses the ESC with all attached sensors for data collection.
- Interfaces directly with the MEGA2560 for data interpretation and storage (connected via ribbon cable).
- Rev1 housed in protoboard unit, transitioned into 4-layer PCB for Rev1.2.

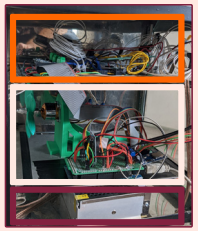
Software Design



- Two fundamental systems of the testbench:
  - ESC Controller
  - Data Logger
- Both systems are integrated into one microcontroller, the Arduino MEGA2560.
- Uses feedback to control ESC power cycling.

Testbench Design

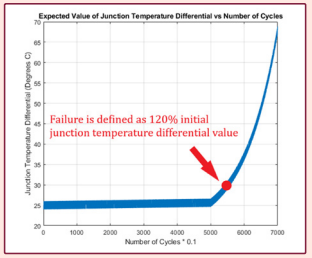
- Multiple parts were designed and 3D printed for the testbench:
  - Core
  - Fan
  - ESC Cap
- 3 Layers to the test enclosure:
  - **Orange** - holds the data logger board, sensors, and ESC.
  - **White** - holds the testbench and MEGA2560.
  - **Maroon** - holds the 12V Power Supply

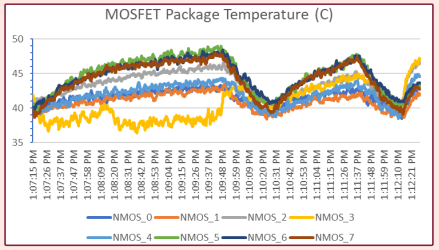


Analysis

$$N_f = a(\Delta T_j)^{-n} exp\left[\frac{E_a}{k_B T_m}\right]$$

Where N_f is the number of cycles to failure, a & n are the experimental coefficients, T_j is the variation of junction temperature, k_B is the Boltzmann constant, E_a is the activation energy, and T_m is the average of the junction temperature.





Remarks

- A future implementation could use a larger fan to induce a greater load, drawing more power and thus increasing the thermal cycling effects on the ESC.
- Designing and adding a thermoelectric cooler to the metal enclosure could enable temperature-control of the testbench, eliminating the ambient-temperature variable during testing.
- Selecting a more open-source ESC such as a VESC would enable part selection (MOSFETs) and datasheet availability for simulations, testing, and evaluation.

Acknowledgments

Sponsor:
Debabrata Pal–Collins Aerospace
Subject Matter Experts:
Shuxiang Yu, Narayan Rajagopal
Mentor:
Kenneth Schulz
Special Thanks:
Toby Meadows

Mars RF Relay System

Jarod Horne, Raymond Daniels, Danny Flynn, Jian Song, Mark Higgins

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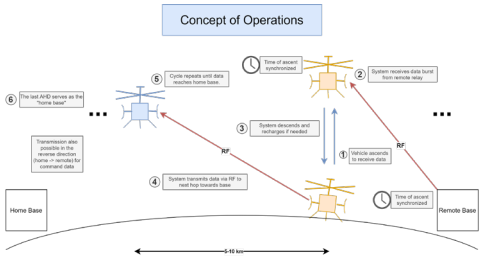
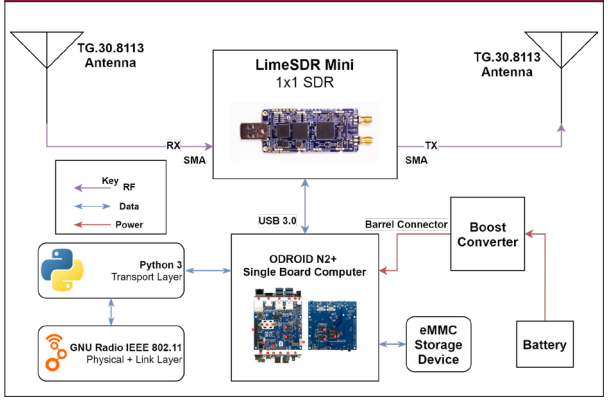
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

Background

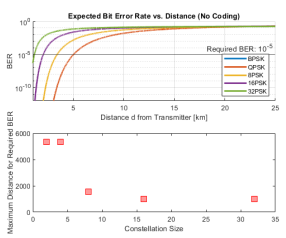


Ingenuity, a small robotic Mars helicopter, recently demonstrated the capability to hover over a location on Mars for a short period of time. This relay system consists of several of these Ingenuity Autonomous Helicopter Drones (AHDs) in a string. The goal of this relay system is to transmit command (text), image, audio, and video data from one end of the string to the other. This project focuses on one of the communication payloads for such an AHD and is designed around size, weight, flight time, altitude, and the Martian environment.

Architectural Design



Subsystem Testing



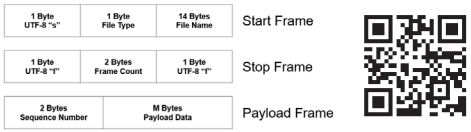
Link budget. *Prior to software implementation, an analysis was performed to determine what modulation could be used to meet the range, data rate, and error rate requirements.*

Power supply testing. *The assembled COTS power supply (bottom left) is shown powering the ODROID N2+ computer with a consistent 12V.*

Key Requirements

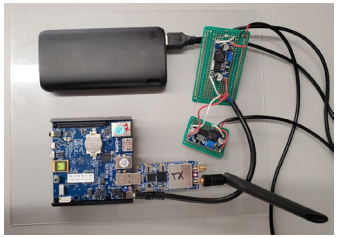
1. Create a system capable of **transmitting text, image, video, and audio files over-the-air** between two AHDs in a string
2. Demonstrate actual **transmission and reception of information over-the-air.**
3. Build **support systems** to supply power to the system, store information received from the next AHD, and hold the system components.

Software Design

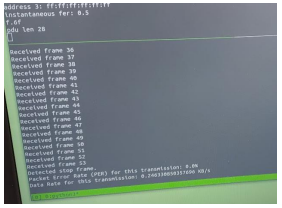


Layered software approach. *Files are broken into frames at the transport layer, which are then sent to the physical layer. The physical layer uses GNU Radio to implement modulation and forward error correction. Scan the QR code to access the software repository.*

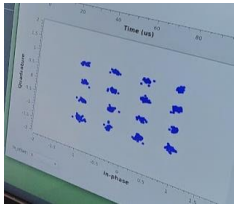
Integrated Testing



Integrated prototype. *Two instances were placed on opposite sides of the room.*



Receiver console output. *This shows successful file transmission with the resulting packet error rate and data rate.*



Receiver constellation diagram. *This shows the 16QAM symbols received over the air.*

Results and Conclusion

Specification	Target Value	Level Achieved
Data Rate	> 2.5 Mbps	1.96 Kbps (over the air) 1.3 Mbps (simulation)
Error Rate	$< 10^{-4}$	0% packet error rate at close range
Range	> 5 km	≈ 3 m
Supply Voltage	0 – 15 V	12 V

- Partial success was achieved with over the air transmission, but the data rates fell significantly short of analysis and simulation.
- Software defined radio introduces intricacies that make it difficult to reach theoretical data rates.
- Be mindful of the voltage polarity on barrel connectors as it can vary between products.

Acknowledgements

We would like to thank Subject Matter Expert and customer Dr. Louis Beex and mentor Professor Toby Meadows for their support throughout this project.

Thermal Integrity Analyzation in ReRAM Arrays

Team Members: Chandler Clements, Max Crochet, Payton Fallen, Zachary Wilson, Shenkai Zhou **SME:** Amrita Chakraborty
Customer: Dr. Marius Orlowski **Mentor:** Prof. Kenneth Schulz

Background

- Resistive Random Access Memory (ReRAM) is a memory storage technology that does not require Silicon.
- ReRam functions using arrays of electrodes that when stimulated form a "**filament**" connection between the electrodes.
- A "**cell**" is the location of a filament connection between Copper (Cu) and Platinum (Pt).

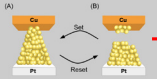


Fig 1: 3-D image of a **cell** changing states

State	Logic Value
(A)	1
(B)	0

Table 1: Cell state Definitions

- Continuous switching of a ReRAM cell causes reliability issue within an array due to heat generation.

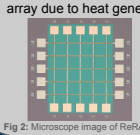


Fig 2: Microscope image of ReRAM devices

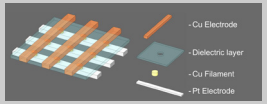


Fig 3: 3-D Schematic of ReRAM Array

Objectives and Approach

- Simulate and analyze heat propagation within the device

❑ Hypothesis: The cell degradation due to heat transfer will be more significant in neighboring cells along the common copper (Cu) line than common platinum (Pt) line.

Fig 4: 3-D Schematic of Heat Transport in ReRAM

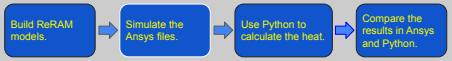


Fig 5: Flowchart of the objectives and approach

Model

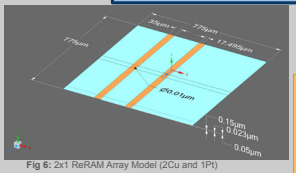


Fig 6: 2x1 ReRAM Array Model (2Cu and 1Pt)

The ReRAM models are built in **Ansys SpaceClaim**.

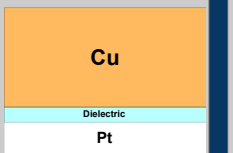


Fig 8: Front view of a ReRAM Array Model

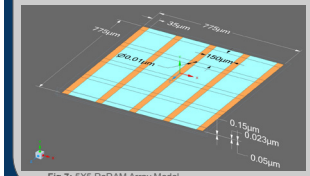


Fig 7: 5X5 ReRAM Array Model

The filament
- Made of Cu
- 10 nm diameter
- 23 nm height

Fig 9: Filament

Energy and Temperature Calculations

- Calculations implemented with **Python**
- Uses given operating voltage/current to calculate energy
- Uses calculated energy to approximate temperature of an electrode

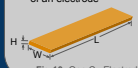


Fig 10: One Cu Electrode

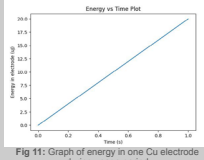


Fig 11: Graph of energy in one Cu electrode during usage period

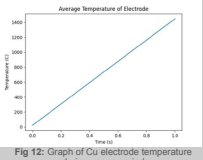


Fig 12: Graph of Cu electrode temperature during usage period

Energy Equation

Q = Voltage * Current * time

Temp Approx. Eq:

$$\Delta T \approx \frac{Q}{\text{Density} * \text{Volume} * c_{p,s}}$$

Where $c_{p,s}$ is specific heat

Simulation Results

5x5 Simulation Properties

- Simulation done in **Ansys Workbench**
- Heat is generated for 100 ms by temperature source of one **filament** at 900 °C
- Cooling is done by convection on top facing materials and ran for entire time
- Total Run time 300 ms or 0.3 seconds
- Ambient Temperature 22 °C
- Heated **Cell** is the switching cell
- Probed **Cell** 1 is the platinum neighbor
- Probed **Cell** 2 is the copper neighbor

Material	Film Coefficient (convection)	Thermal Conductivity
Copper	13.14 W/m^2 * C	**400 W/mC**
Platinum	Not under convection	**72 W/mC**
Dielectric (silicon Dioxide, SiO_2)	1.2 W/m^2 * C	**1.5 W/mC**

Table 2: Material values in Ansys Workbench

Start of Heating

- *Figure 13* is at time 10 ms or 0.01 seconds
- Maximum surface temperature is 174.34 °C
- #1 Probed surface temperature is 53 °C
- #2 Probed surface temperature is 120 °C

End of Heating

- *Figure 14* is at time 100 ms or 0.1 seconds
- Maximum surface temperature is 400 °C
- #1 Probed surface temperature is 220 °C
- #2 Probed surface temperature is 300 °C

Start of Cooling

- *Figure 15* is at time 102 ms or 0.102 seconds
- Maximum surface temperature is 264.74 °C
- #1 Probed surface temperature is 238 °C
- #2 Probed surface temperature is 261 °C

Deep into Cooling

- *Figure 16* is at time 250 ms or 0.25 seconds
- Maximum surface temperature is 35.84 °C
- #1 Probed surface temperature is 35.8 °C
- #2 Probed surface temperature is 35.81 °C

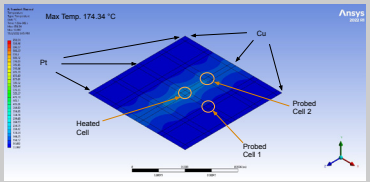


Fig. 13: Start of Heating

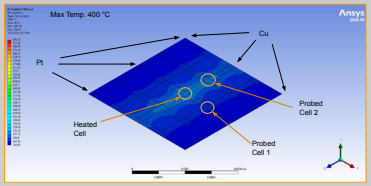


Fig. 14: End of Heating

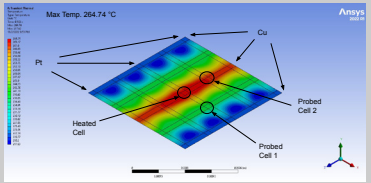


Fig. 15: Start of Cooling

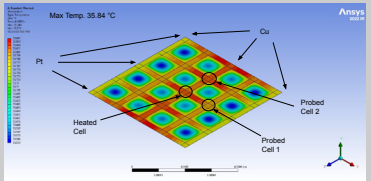


Fig. 16: Deep into Cooling

Analysis and Conclusion

$$D\% = \frac{\text{MNSC of a fresh cell} - \text{MNSC of a probed cell}}{\text{MNSC of a fresh cell}}$$

MNSC (maximum # switching cycles of a fresh cell)
D% = percent degradation

Electrode	D% of First Neighbor Cell	ΔT at 10ms	ΔT at 100 ms
Cu	80	120 °C	300 °C
Pt	67	53 °C	220 °C

Table 3: Temperature Data from Simulation Results

❑ Hypothesis: The cell degradation due to heat transfer will be more significant in neighboring cells along the common copper (Cu) line than common platinum (Pt) line.

Script validation concludes that Cu Electrodes **reach temperatures of 1085 ℃** at around 700 ms, without considering convection and radiation losses.

Challenges

- Resolution limits of most modeling software prevents modeling of filament.
- Ansys Workbench does not contain proper dielectric material (Tantalum Oxide).
- No way to physically conduct heat measurements, thus lacking physical validation.
- Meshing requires the bridge between objects with dimension differences of three orders of magnitude.

Future Work

- Scope of validating thermal simulation results through experimental characterization.
- Study thermal effects for varying dimensions of ReRAM arrays.
- Heat Calculation Script modification to account for exact Newtonian losses.
- Re-scale simulation for comparison of industry models.

Acknowledgements

We would like to acknowledge the following people for their support!

- Dr. Marius Orlowski (Customer)
- Kenneth Schulz (Mentor)
- Amrita Chakraborty (SME)

TRACK 3

Ellett Valley

Toby Meadows

Master of Ceremony

Mike Penzo

Judge

Medication Compliance

Computer Vision Mobile App Based Blister Pack Analysis

Alex Parrott | Alban Lu | Daniel Shin | Hansu Kim | Jiaye Liu

Customer: Impruvon Health | Justin Amoyal (CEO)
Subject Matter Expert: Dr. Creed Jones
Mentor: Dr. Scot Ransbottom

Problem Statement

In care agencies across the country, over 800k medication errors occur that are preventable.

- Almost 4 hours are spent per shift by staff just managing medication.
- The time spent managing medication is due to a time consuming, error prone, manual process.
- Impruvon equips every team member in the medication management environment with the technology needed to automate the previously manual process.
- The main contributor of errors is not knowing what medications are in a pack, in inventory, or if they have been tampered with.

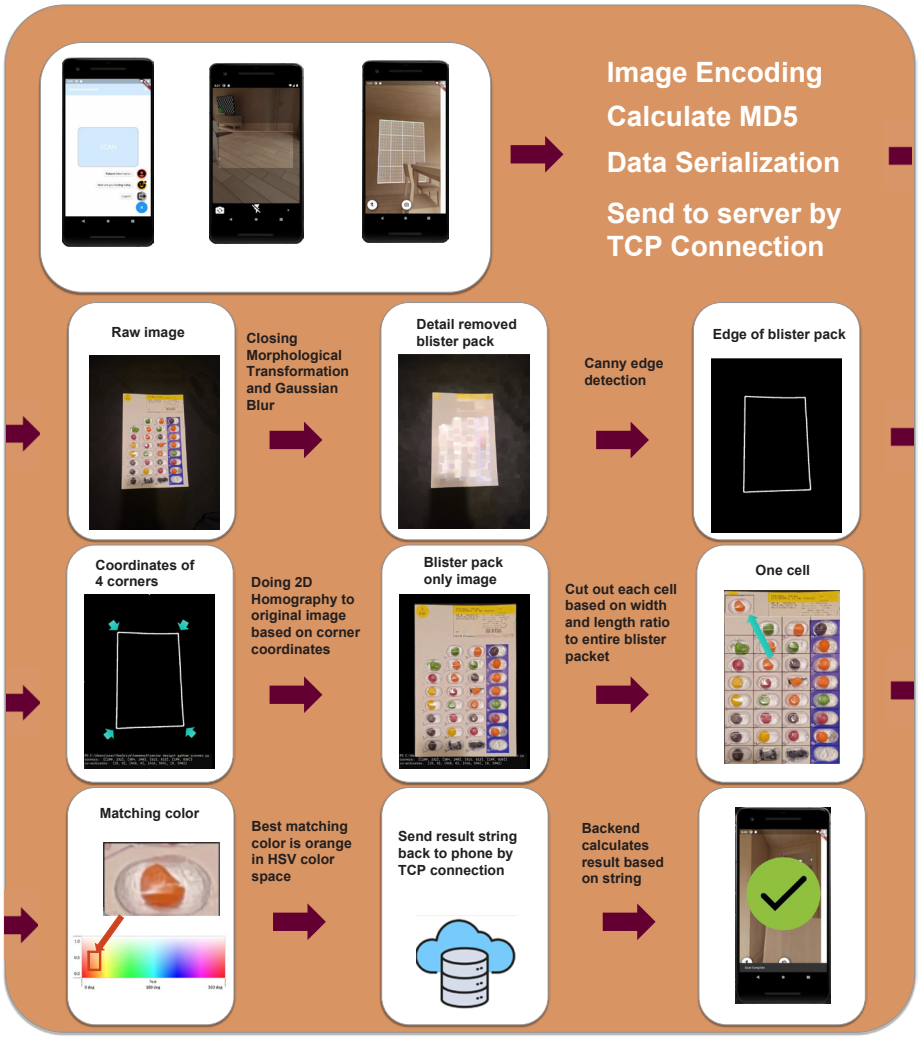
Design Objectives

- Develop app interface that allows user to scan a barcode and blister pack.
- Utilizes the app or server to use the image taken to identify medication within the blister pack.
- Use the mobile phone for hardware (camera, communication, processing).
- The design must be able to relay results to and from server in near real time.
- The design must be capable of sharing results with Impruvon back-end to display on front-end.
- We were tasked with developing a mobile app software since their platform is app based.

Design Constraints

- The solution could not modify the standardized blister pack (standard set by industry).
- The solution cannot be invasive, ingested, or attached to the patient.
- The solution cannot physically interact with the medicine.
- The solution must be able to communicate in near real time incase emergency services are needed.

Project Path



Results Delivered

- Functional android application.
- User is able to scan barcode and image the blister pack.
- Use additional features such as dark mode and patient well being function.
- Server for image processing software that can detect pills in each cell using color detection.
- Server can communicate with client device and administrators to show analysis results.

Challenges

- Design was hardware based.
- Deliverable was an enclosed imaging tray that could be inserted into lock box.
- Due to customer discovery and poor image quality the design was altered.

Future Efforts

- Connect FDA medication database to computer vision software.
- Enhance computer vision software with more steps to verify a blister pack's status.
- Improve back end communication security.
- Develop a way to detect pills with a changing background.
- Improve aesthetics and additional features of android app design.
- Develop GUI for iOS devices.
- Develop computer vision software for pill shapes and sizes to accompany color detection.

Acknowledgement

- Mr. Justin Amoyal and Impruvon Health
- Mr. Michael Quinones and Blacksburg Pharmacy
- Subject matter expert, Dr. Creed Jones
- Mentor, Dr. Scot Ransbottom

Reference

[1] "Patient Safety Facts ," DataRay USA, 17-Dec-2019. [Online]. Available: https://dataray usa.com/resources/stats/. [Accessed: 23-Oct-2022].
[2] NORC at the University of Chicago and IHI/NPSF Lucian Leape Institute, "Americans' experiences with medical errors and views on patient safety," Institute of Health Improvement, May-2017. [Online]. Available: https://www.ihi.org/about/news/Documents/IHI_NPSF_NORC_Patient_Safety_Survey_2017_Final_Report.pdf. [Accessed: 23-Oct-2022].
[3] C. Morgan, "Prevention of medication errors in assisted living facilities," Caitlin Morgan Insurance Services, 19-Apr-2021. [Online]. Available: https://www.caitlin-morgan.com/recognizing-preventing-medication-errors-in-alfs/#:~:text=Another%20study%2C%20this%20time%20conducted,in%20long%2Dterm%20care%20facilities. [Accessed: 04-Nov-2022].

Medication Tamper Control and Dispensing Unit

Sponsor: Justin Amoyal

Members: Taotao Wang, Abdul Hadi Imran, Yeab Bahru Lakew, Shane Smith, Kyle Bugeja

Faculty Advisors: Dr. Creed Jones

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BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

Overview

Issues with incorrect medication administration in long term care facilities already take 7000 - 9000 lives annually, with dispensing incorrect medication being one of the leading causes of death. [2][3] With the number of patients in healthcare facilities expected to reach **30 million people by 2050**, it is important that we find a way to minimize medication administration errors. [1]

Our design seeks to do just that by facilitating record keeping for patients' medication and ensuring that only specified dosages of medication can be accessed at any given time, thus aiding overwhelmed medical professionals with their workload.

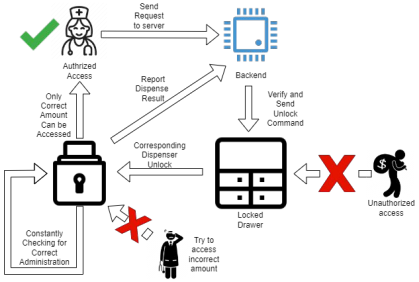


Figure 1. The overall process diagram of our design

Objectives

The success of our design will be gauged by its ability to:
1. **Dispense** medication via an internal dispenser.
2. **Track** data regarding medication stored.
3. **Prevent** medication tampering and theft.

Design

The whole system will consist of seven drawers. Each drawer will contain nine individual slots that will be able to dispense a patient's medication stored as a pill pack sleeve.

Full Drawer System

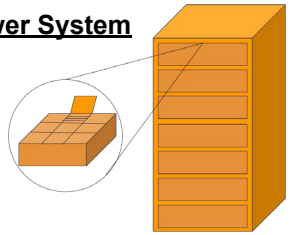


Figure 2. The 7 drawer system with each drawer containing 9 dispenser slots

Each one of the nine slots in the drawer will be stocked with a sleeve of pill packs that contain a patient's dosage for a particular period of time. To ensure that the medication stored within the unit is secure, each slot is outfitted with electromagnets to allow for the automatic remote locking for each unit at the end of each dispensing process.

Medication Storage Slot

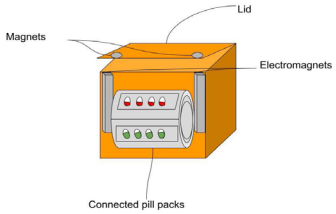


Figure 3. An internal view of one operating dispenser slot

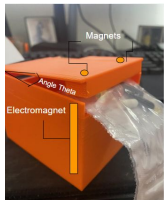


Figure 4. The design of the final prototype

The operator would be responsible for selecting which slot to access as well as providing authentication to access the stored medication. The microcontroller driving the system will access the requested slot based off its device ID, open only that slot, dispense the required dose, and close again once the pill pack has been removed.

Conclusions

Overall, we believe our final prototype delivers on the design objectives we sought to accomplish. The storage slot is successfully able to dispense medication and prevent medication tampering and theft. A demonstration of the prototype's action can be seen by accessing the QR code below.

Future Works

Given more time to work on this design, our team would seek to further simplify the system's use by allowing for individual drawers to be assigned to different nurses. Additionally, we would try to further improve system functionality by making it possible to see a patient's medication type and dosage upon entering their name.

References

[1]. J. 2019, "Number of older adults with long-term care needs will triple by 2050, Paho warns," *PAHO/WHO | Pan American Health Organization*, 01-Jan-2019. [Online]. Available: https://www.paho.org/en/news/1-1-2019-number-older-adults-long-term-care-needs-will-triple-2050-paho-warns. [Accessed: 24-Oct-2022].

[2]. Y. Scherbak, "Medication dispensing errors and prevention," *National Center for Biotechnology Information*. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/30085607/. [Accessed: 25-Oct-2022].

[3] "Concepts in managed care pharmacy," *AMCP.org*. [Online]. Available: https://www.amcp.org/about/managed-care-pharmacy-101/concepts-managed-care-pharmacy. [Accessed: 27-Oct-2022].

Geolocation Scanning Rig

Team Members: Luke Smith, Hunain Ali Shamsi, Priti Yadav, Minzhou Pan, Shiqian Li

Customer: PricewaterhouseCoopers **SME**: Tim Talty **Mentor**: Shelley Stover

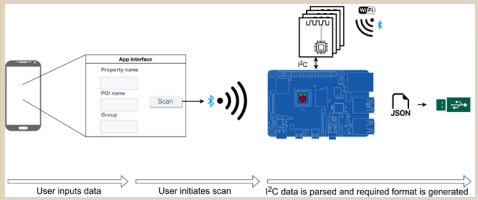
Motivation

Industries spend millions of dollars in staff time searching for lost equipment and finding people in need. To accurately track the location of one's most critical assets, PricewaterhouseCoopers proposes a beaconless solution that leverages pre-existing signals and their strengths to create a unique fingerprint for each room or major space of a property.

Objectives

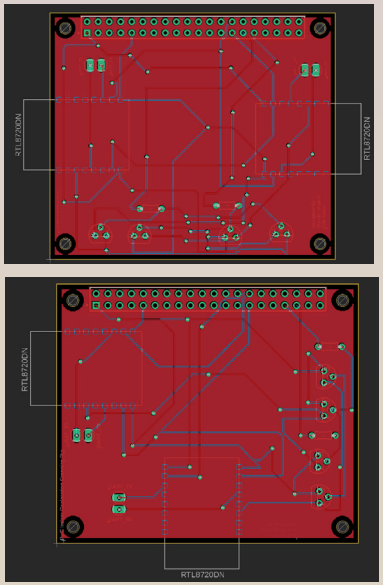
- Battery powered with operating time >24 hours
- Form factor should be within standard luggage size (21"x14"x19") and under 20lbs
- Gather identifiable information from nearby 2.4 GHz and 5.0 GHz Wi-Fi access points
- Gather identifiable information from nearby Bluetooth Low Energy (BLE) emitting devices
- Complete 10 scan sequences within 60 seconds
- Develop an Android mobile app that allows a user to supply location information, trigger a scan, and display scanning progress

System Overview



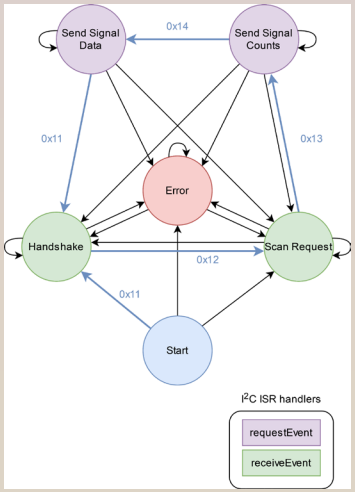
Design Process

PCB Design



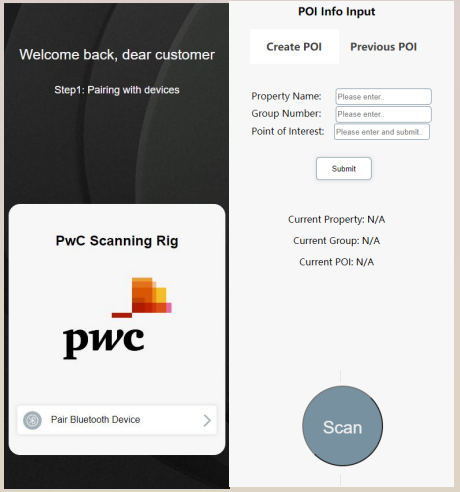
The PCBs were 2-layered and included two Wi-Fi/BLE modules each in opposite directions, a transistor based circuit to reset the modules, and the RPi GPIO header.

Embedded Software Design



Each microcontroller unit (MCU) sends and receives data over an I²C bus to/from the single-board computer (SBC). The SBC contains a BLE server that enables communication with the mobile app which is used to trigger a scan on the MCU. Once the MCU has finished scanning, the data is transmitted over the I²C bus to the SBC where it is parsed and the target payload is constructed.

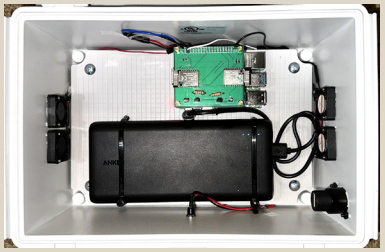
Mobile App



The mobile application is developed using HTML, CSS, and JavaScript. It contains a graphical user interface that uses GATT Bluetooth Low Energy protocols to set up a connection between the App and Scanning Rig. It allows users to supply location information, trigger a scan, and display scanning progress.

Video Demonstration

Final Product



Challenges

- Connectivity and design issues with the PCBs
- Overheating concerns with the enclosure
- Concurrent scanning issues with multiple modules
- Low-level hardware abstraction functions of microcontroller API are closed source

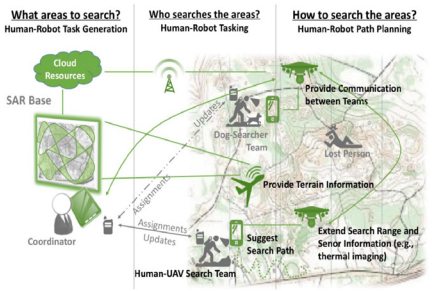
Search and Rescue Robot Swarm

Team: Alejandra Caceres, Mahmoud Elsayed, Mohammed Zaheer, Osama Owis
Sponsor: Collins Aerospace **Mentor:** Prof. Toby Meadows **SME:** Dr. Ryan Williams

Background

Distributed path planning systems have a great chance to provide value. It is an advantage that many industries can benefit from. Search and rescue missions is one such aspect where a swarm of drones can help human operators to find lost individuals.

In a Search-and-Rescue setting, time is of the essence. Every hour that passes, the chance of finding the individual diminishes. Therefore, our goal is to implement a fast and efficient decentralized path planner that reaches identified goal locations while avoiding obstacles.



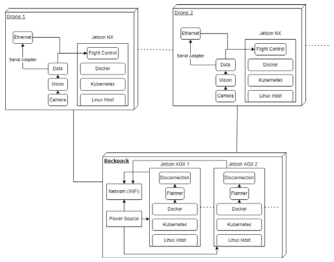
Objective and Key Requirements

Create a path planner for the drones to find the target utilizing kubernetes and prove scalability to multiple drones. Next, design protective equipment for the drones and the computational backpack.

Key Requirements:

- Simulation of the Drone's path planning finding the target while avoiding obstacles
- Demonstration of In Field Testing
- Enclosure prototypes for Backpack & Drones

Overall System Architecture



Path Planning Approach

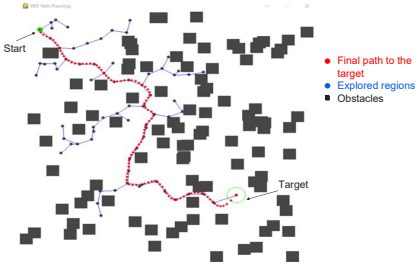
Our path planner takes random configurations from the space sample and makes a connections between its nearest state and the random state. If there exists an obstacle or a constraint, no connection will be made and subsequently the new random state will not be added to the search tree.

An analysis of the random sampling method implemented provides great insight. The use of a uniform random sampling shows that the probability of sampling is proportional with the size of its own Voronoi region. This means that the tree search expands with preference to unexplored regions. This coupled with the biased search implementation, results in quick exploration of the map.

Random Point Sampling

Path Planning Results

Simulated experimentation of the algorithm results in the agent finding the goal in a densely occupied map with obstacles while avoiding them. This happens in a quick and efficient manner as calculations barely take any time.
The path planning algorithm was also tested in the actual fields with drones and using GPS coordinates. The test scenarios used one drone and two drones separately. Both tests resulted in successful outcomes as the drones made their ways to the goals while avoiding simulated obstacles.

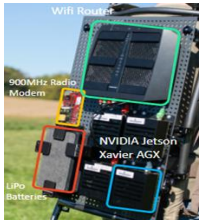


Simulation of Drone Path as it Avoids Obstacles

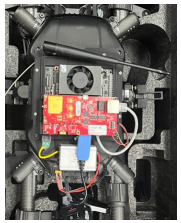
Field Test of Path Planner as it Avoids Virtual Obstacles

Exposed Hardware

The existing hardware components are incredibly susceptible to weather conditions such as rain.



Exposed Backpack Hardware

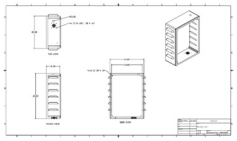


Exposed Drone Hardware

Hardware Enclosure Designs

Backpack Enclosure Design Features:

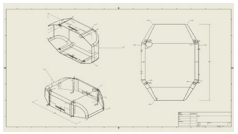
- Avoids Heat Buildup
- Easy Internal Access
- Water resistant



Backpack Enclosure Design

Drone Enclosure Design Features:

- Easy Internal Access
- Light Weight
- Water resistant
- Aerodynamic



Drone Enclosure Design

Field Test Run Video

Challenges

- Defining project scope was a major challenge in the beginning
- Implementing trajectory smoothing to the path
- Difficulty in scheduling field testing for drones
- Technical difficulties during field testing
- Meeting deadlines

Conclusion and Future Work

In Conclusion:

- Our solution quickly finds a path every time to a goal location in an obstacle filled space.
- A simulation was made that creates a quick route to the end goal
- The path planner was tested within the field and was verified by using two drones
- The path planner can easily be scaled up to more drones
- Two hardware enclosures were designed: one for the backpack and one for the drone

To Further Improve this Project:

- Implement multi drone coordination
- Generate more optimal paths
- Build and complete testing for the hardware

Acknowledgements

The team would like to thank the following people for their support throughout the project:

SME: Dr. Ryan Williams
Graduate Team: Larkin Heintzman, Kevin Smith
Mentor: Prof. Toby Meadows
Collins Aerospace Representatives: Giovanni Franzini, Marcello Torchio, Stefano Riverso

Wireless Control Algorithms

Wireless@VT
Dr. Carl Dietrich

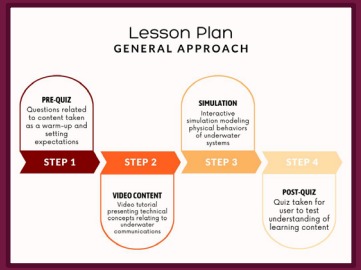
Connor Mcpeak, Hitesh Kumar, Mpeh Ntantang, Joshae Gordon, Kaushiki Valluri

Purpose

- Introduce users to challenges and opportunities associated with the radio frequency spectrum as well as the acoustic spectrum.
- Outline the differences between terrestrial and underwater communications.
- Provide the users with hands-on learning experiences in a self-paced, online format.

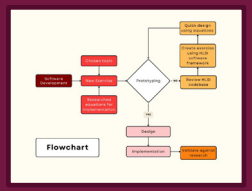
Objectives

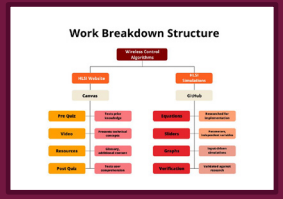
- Create five exercises discussing Underwater Communication.
- Engage learners using multiple mediums and resources.
- Provide interactivity through game-like simulation exercises.
- Use pre/post quizzes to set learners' expectations and assess knowledge gains and course effectiveness.



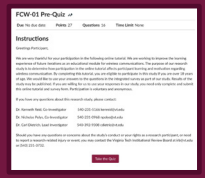
Design Process

- To ensure validity, the resulting simulations created were compared against researched graphical representations.
  - Part of the verification process is validation from Dr. Jakubsin of the Virginia Tech Hume Center.
- The final result is five refined Canvas pages with user interfaces and usability features which allow users to easily navigate through each exercise.
- Each exercise's Canvas page includes the pre-quiz and post-quiz questions, background information, background video, HLSI simulation, glossary, and additional resources.

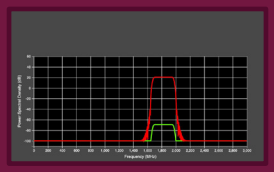




Final Deliverable



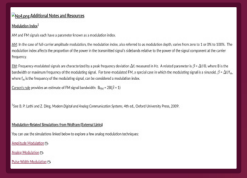
(1) Pre Quiz -
Created to set learners' expectations



(3) Simulations -
Final interactive graph on the website

(5) Post Quiz -
Test knowledge gained and course effectiveness

(2) Background video -
to teach the learners the information



(4) Additional resources

Challenges

- Null graph readings of underwater path loss equations and other equations.
- Adapting to HLSI software framework which impeded progress with new equations.
- Different levels of understanding of HTML and not learning through school curriculum.
- Transposing log domain equations to linear domain equations to accurately simulate underwater environments.

Lessons Learned

- Hesitancy in asking for help and clarifying requirements from customer will set back progress.
- Working in agile is preferable for software development work and helps with productivity.
- Soft skills are equally as important as technical skills in any project and without balance, projects cannot progress efficiently.

Acknowledgement and Future Plans

- The team gratefully acknowledges Dr. Dietrich, Professor Schulz, Dr. Jakubsin, and Wireless@VT.
- Future plans consist of adding more information and detail to simulations, and coalescing all existing material onto a single website.

SELECT 2804 POSTER

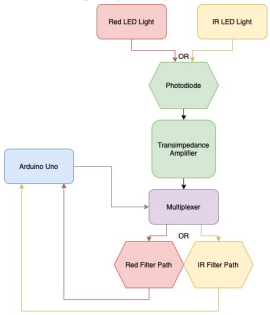
SpO_2 & Heartrate Instrument Project

Mason Lopez
Professor Md Adnan Sarker
Department of Electrical and Computer Engineering, Virginia Tech

Introduction

In this project I was assigned to develop a device that measures SpO2 of a user as well as measuring heartrate and displaying the signal onto an OLED display. Using Arduino Uno, protoboard, Nelcor finger sensor, LF356 op-amps and multiplexer I was able to create a low cost, accurate SpO2 and heartrate monitor device. This project was created as part of the Integrated Design Project course, under the Department of Electrical and Computer Engineering.

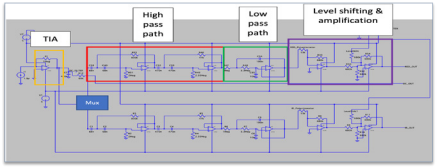
Overview



Flow Path

The LEDs emit light into user's finger, the light not absorbed by the blood's hemoglobin is received by the photodiode on the other side of the LED's. The photodiode outputs a current of which has no use, so it must be input to a transimpedance amplifier which converts this tiny current into a noisy voltage. Then this signal gets inputted into its respective filter path where it gets cleaned and amplified and then gets inputted into the Arduino where it can get sampled and displayed onto the OLED.

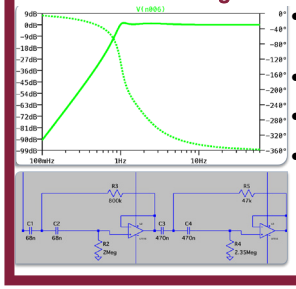
Schematic



Filter Design

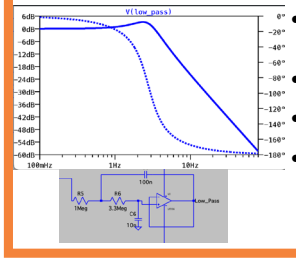
Analyzing the signal straight from the transimpedance amplifier will show a signal that is corrupt with 60Hz frequency power noise, along with lower frequency DC noise that makes the signal appear to shift up and down due to ambient light. Hence creating high pass and low pass filter is necessary to rid the noise and get a pure signal that contains only the frequencies we care about. These frequencies are in the range of about .9Hz to 4Hz, as these frequencies directly map to BPM by multiplying the frequencies by 60.

High Pass Filter



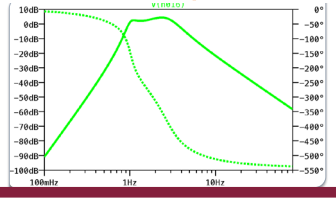
- Fourth order Chebyshev high pass filter
- Cut off frequency of .9Hz
- Gain of 0dB
- Removes low frequency noise such as ambient light

Low Pass Filter



- Second order Chebyshev low pass filter
- Cut off frequency of 4Hz
- Gain of 0dB
- Attenuates 60Hz at -50dB

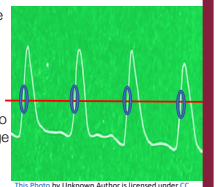
Overall Response



Arduino Algorithm

Aside from designing the hardware portion of this project, there still relies a major portion of this project that requires developing algorithms. These algorithms includes detecting and displaying heartrate as well as calculating SpO2 measurement of the user.

Calculating Heartrate

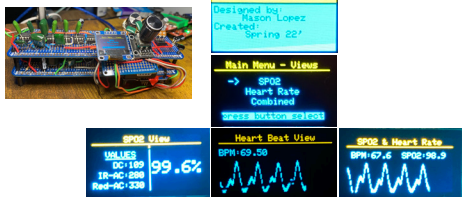


To calculate the heartrate of the user I sampled the red LED's filter pin every 5 mS, each time saving the analog value to an array which has a length the size of The OLED display (128 pixels → 127 usable), As well as being mapped to a value that Graphs to the OLED display in real time. After the display is filled, hence the array as well, the Arduino loops through the array And calculates the average value, and then loops Through again and records the times the values cross the average while also Noting where the first and last index this occurred. Knowing the time, it takes to fill the entire screen as well as the width/index of the screen I can find the *time per index*. This is particularly useful when you take the difference delta of first and last index and multiply by *time per index,* this gives the period where the beats took place, which is crucial to calculating an accurate heartrate of a user. Finally, to find BPM it is then equal to # beats/period of beats * 60.

Calculating SpO2

To calculate SpO2 of a user you must use a combination of both LED's to measure their AC signals, using the formula $r = (AC_{red}/DC)/(AC_{IR}/DC)$, which then gets plugged into SpO2 = 125 – (25*r). In order to use this formula, you must get the AC values of each LEDs at same time, or as fast as possible, hence I used a multiplexer controlled by Arduino via 1kHz all while reading the AC value for each LED and DC value.

Pictures & UI



Contact

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